NAIC-ID(RS)T-0302-95

NATIONAL AIR INTELLIGENCE CENTER

AIR INTELLIGENCE AGENCY

COLLECTION OF THE WORKS OF EREVAN HYDROMETEOROLOGICAL OBSERVATORY

RELEASE I.

NATIONAL AIR INTELLIGENCE CENTER

**Approved for public release:
distribution unlimited**

PARTIALLY EDITED MACHINE TRANSLATION

NAIC-ID(RS)T-0302-95 6 September 1995

MICROFICHE NR: 95C000561

COLLECTION OF THE WORKS OF EREVAN HYDROMETEOROLOGICAL OBSERVATORY RELEASE I.

English pages: 186

Source: Sbornik Rabot Yerevanskoy Gidrometeorologicheskoy Observatorii, Nr. 1, Yerevan, 1966; pp. 1; 5-19; 22-133

Country of origin: USSR
This document is a machine translation processed by:
Input: David Servis, Inc.
F33657-87-D-0096
Post-Edit: SrA Tanja M. Wright
Quality Control: Nancy L. Burns
Requester: NAIC/TASC/Lt Shaun M. McMahon
Approved for public release: distribution unlimited.

TABLE OF CONTENTS

U.S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM ii

SYNOPTIC-CLIMATIC CHARACTERISTIC OF ARMENIAN SSR, by G.O. Kirishchyan 2

WIND CONDITIONS OF THE TERRITORY OF ARMENIAN SSR, by A.G. Nersesyan 22

HEAT BALANCE OF LAKE SEVAN, by M.M. Aynbund 60

MANY-YEAR OSCILLATIONS OF THE RUNOFF OF THE RIVERS OF BASINS KASAKH AND ARGICHI, by S.M. Musaelyan 145

SOME SPECIAL FEATURES OF THE WINTER CONDITIONS OF THE TEMPERATURE OF SHELTERING VITICULTURE, by R.S. Mkrtchyan, A.M. Kirakosyan, Z.V. Sadoyan, L.S. Khachatryan 164

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

Collection of the works of Erevan hydrometeorological observatory.

RELEASE I.

Edited by M. M. Aynbund.

Page 5.

SYNOPTIC-CLIMATIC CHARACTERISTIC OF ARMENIAN SSR.

G. O. Kirishchyan.

The territory of Armenian SSR is subjected to the effect of the masses of air, which are spread from the moderate and subtropics. In the cold season the possibility of the penetration of cold air from the Arctic Basin is not excluded, while into the summer period - the penetration of the warm air masses of air from the tropics.

From average charts of high-altitude pressure field, shown in the appendix in the work of Kh. P. Pogosyan [4] it is apparent that the west-east air-mass transfer rules above Caucasus for the course of the entire year. G. D. Zubyan and Kh. P. Pogosyan [2] noted, that in the cold season this transfer is retained also at the height 700 mb. of surface, and in summer predominates transfer from the south to the north.

The examination of aerosynoptic material within the period from 1944 through 1955 completely confirmed the special features for the territory of Armenian SSR indicated. It is clear from the weather maps that the territory of republic is subjected to cyclo-anticyclonic activity and frontal processes, which most actively occur into cold half of year. On the basis of the conditions of circulation, and also effect of orography, is examined the conditions of weather in the

republic on the seasons of year.

Page 6.

From average chart of the distribution of air pressure on the earth's surface [4] it is evident that during January Caucasus is subjected to the effect of the southwestern part of the anticyclone, whose center is located above the continent of Asia. This situation in the territory of Armenian SSR causes the predominance of weather with stratus clouds and with the precipitation of small precipitation, and sometimes leads to the complete clearing, especially in the night time. The cases, when the trough of cold is oriented in the meridional direction to the regions east of Caucasus and in the territory of Armenia the cold only penetrates the lowest layers, and above there is extended warm ridge, are also frequent. In this case the lapse rate of air is very small, even negative; thick inversion layer causes stratus clouds, by places clear weather. The frequent frequency of this structure of thermobaric field causes in Armenia minimum amount of precipitation precisely in winter.

From the materials of many-year observations it appears, which in each winter month falls 2-5% of annual total precipitation. Basic part of the precipitation is caused by their daily maximums. The daily amount of precipitation, which can occur in winter period, composes 30-40% of many-year monthly total precipitation, or 1-2% of many-year annual total precipitation. Consequently 2-5% of annual amount of precipitation or 1-2% falls on the precipitation, which

falls in the days during the day with the maximum amount of precipitation.

Night clearings cause strong night radiation of heat from the underlying surface and considerably chill air layers adjacent to them. This especially is sharply pronounced in the valleys and in the mountain plateaus. On the latter the temperature of air is strongly reduced, and in the small layer, creating ground inversion. Therefore the absolute minimums of the temperature of air frequently in the valleys and in the plateau are considerably lower than at slopes and mountain peaks. The data, given in Table 1, can serve as striking example.

Page 7.

Cooling depends also on orographic special features, form of the relief of the underlying surface.

Strong cooling in winter occurs in the Leninakanskoye and Aparanskoye plateau, where at the heights 1500-1900 m the absolute minimum of the temperature of air reaches 41° frost.

In the Araratskoy plain at the height of 800-900 m frost reach 33° (Oktemberyan). In the basin of Sevan lake, in spite of its gap form, the thermal mode of surface boundary layer of another, due to the softening effect of basin. The bottom of basin (lake) is located on the height of approximately 1910 m, observation sites at heights

1920-1950, and the absolute minimums of the temperature of air oscillate in limits of 33-41° frost. In Shorzhe and in the peninsula Sevan, located directly on the water surface, the minimum composes 28° frost, which only is 6° lower than at the very southern point of the republic (Megri), located at 691 m.

Into the cold half-year above Transcaucasia is also considered the effect of troughs of cyclones, moving from the Black Sea to the northeast of the European territory of union. N. N. Bel'skoy [1] calculated, that 57% of all these cyclones are observed in the period from January through March.

The troughs of the cyclones indicated frequently are directed to Transcaucasia, causing weather with the precipitation.

Table 1.

(a) Название пункта	(b) Высота (м)	(c) Абсолютный минимум температуры воздуха	
		(1) за многолетие	(2) за 1961 г.
(3) Шурабад	2027	—46°	—42,2°
(4) Ерагумбер	3101	—	—29,5°
(5) Арагац в г	3229	—39°	—30,8°

Key: (a). Name of site. (b). Height (m). (c). Absolute minimum of the temperature of air. (1). for many years duration. (2). for 1961. (3). Shurabad. (4). Yeratumber. (5). Aragats city.

Page 8.

Daily maximum amounts of precipitation by winter are observed in essence during this synoptic situation. The maximums of the temperature of air in the cold half-year are observed in the warm sectors of these cyclones. Absolute maximum temperatures of air are positive in the course of the winter months in all observation sites.

In spring above Caucasus cyclonic activity is amplified. Upon meridional conversion of deformation field in the troposphere and intensive cold advection in the region of upper level trough, extended to the south, the frontogenesis is amplified.

The presence above Caucasus of this structure of the thermobaric field of the lower troposphere, when the advection of unstable cold masses of air occurs, favors development in the territory of Armenian SSR, shower and thunderstorm activity [3].

Shower thunderstorm activity in the territory of republic is most strongly expressed during May and June, when thermal and turbulence is superimposed to the general instability in the troposphere and turbulence, which develops in surface boundary layer as a result of overheating of the underlying surface.

In spring frequently occurs the intrusion of very cold masses of air, causing in the republic the late frosts, which cause large damage to agriculture. These "cold returns" can cause very low temperatures and snowfall even in the low regions. The absolute minimum of the temperature of air is very low because of these intrusions during March. In the northern regions it differs little from the winter minimums. Values of the absolute minimums of the temperature in the republic even during May, almost everywhere is negative.

Average from the absolute minimums of the temperature of air during April in the entire territory, eliminating only Megri, is lower than 0°; in the zone of above 1500 m above sea level it remains negative and during May.

Page 9.

The efflux of the warm air masses of air from the south causes before the warm front precipitation of strong, mainly heavy rains. After the cessation of this precipitation during April or May spring maximum temperatures of air can be observed.

Amount of precipitation from April sharply increases and at the same time shower thunderstorm activity is amplified.

The greatest daily amounts of precipitation are observed, in essence, in the spring period; in Gorise it is equal to 99 m, in Semenovke 94 mm. In the number of sites of maximum daily amount of precipitation varies in the limits of 70-80 mm. These have shower nature and very intense nature. Frequently they fall during the very short time interval (several hours). Under appropriate conditions these precipitation in the small mountain creeks strong shower causes seasonal and torrential floods.

In summer above Caucasus considerably decrease horizontal baric and lapse rates, frontogenesis is substantially weakened. Above Caucasus at the heights frequently is observed warm ridge, and on the earth's surface gradient-free field. Frequently Transcaucasia is under the effect of the Iranian thermal depression. Warm air penetrating from the desert spaces of front Asia, is very dry, frequently strongly covered with dust, which leads to dry, hot, cloudless weather.

Absolute maximum temperatures of air in the territory of republic in summer is in essence connected with this synoptic situation.

In summer prevailing deposits of shower nature, caused by the meridional conversion of the thermobaric field, when cold trough

occurs directed in Caucasus. The sharply pronounced daily variation of cloudiness is observed upon invasion of cold air above the entire territory of republic.

Page 10.

In the morning hours it is frequently cloudlessly or light cloud; in the daytime as a result of the development of the thermal convection, to which is connected the dynamic turbulence, caused by orography, is formed the thick convective cloudiness, from which in second half of day and first half of night frequently falls shower precipitation with the thunderstorm, scattered very strong. The prevailing number of cases of these precipitation is observed between 18 and 21 hours. The cloudiness begins to be scattered in the morning. Because of the separate strong rains the annual minimum of precipitation does not fall on the summer months, with exception of the Araratskoy plain, where the precipitation insignificant and their annual minimum falls precisely on the summer. Thunderstorm activity in summer considerable, thunderstorms frequently are without the precipitation.

Invasions of cold air even in the summer months in the separate regions cause minus temperatures of air. Absolute minimum temperatures of air during June in Shurabade if 5° frost, in Leninakan 3° frost, in Kama 5° frost, at the high-mountain station Aragats 9° frost, in Araratskoy plain of 5° heat. However, average values of absolute minimums are positive, with exception of separate regions as, for example, Shurabad (-1°), Aragats v/g (-5°).

Summer maximum temperatures of air are observed during July or August.

On the vertical zones the gradient of the maximum of temperature reaches dry adiabatic value and even exceeds it. This leads to the rapid development of convection, and since in summer above the territory of republic the frequency of warm dry air large, during this intensive convection the formation of clouds, especially above the plains part, occurs rarely. Only in the mountain regions sometimes are formed the thin clouds, which can rapidly be eroded.

The circulation conditions of September strongly do not differ from summer and only from October sharply is amplified the inter-latitudinal exchange of air. Above Caucasus is amplified the frontogenesis and cyclo-anticyclonic.

Page 11.

From the direction of Mediterranean and Black Seas in Transcaucasia increasingly more frequently penetrates warm humid air, with which in Armenia are observed the heavy rains, which are at times continued up to 2 days and more. Cold air in the lowest layer of the atmosphere in Transcaucasia invades from the direction of the Black and Caspian Seas. Cold air, being moved from the side of the Black Sea, leaves a significant part of its moisture on the windward side of the Georgia mountains and Armenia penetrates considerably impoverished

by moisture. The same air, penetrating from the side of Caspian Sea, on its way meets less mountain obstructions, especially upward on the valleys of the rivers of Kury and Agstev, and it invades Armenia with a comparatively large moisture content. During this situation the propagation of cold air from the direction of Caspian Sea causes precipitation of larger amount of precipitation, than during the penetration of the same air mass from the direction of the Black Sea. This air reaches the Araratskoy plain so impoverished by moisture that only insignificant cloudiness there frequently is observed.

Because of the intensification of cyclo-anticyclonic activity in autumn in the territory of Armenia is observed the second less expressed maximum of precipitation (during October, scattered during November). This maximum in the republic are approximately 40% of first spring-summer maximum of precipitation, and in the Araratskoy plain reaches even 60-70%. The latter can be explained by the fact that the in autumn underlying surface in the Araratskoy plain is stronger it is thoroughly heated and the intensive development of thermal convection contributes to an increase in the instability of humid air and to precipitation of strong shower precipitation.

In autumn the temperature of air considerably higher than spring. The absolute minimum of the temperature of air from September almost throughout entire territory is negative. Average from the absolute minimums temperatures from the middle of November throughout entire territory are negative.

Page 12.

In autumn early frosts and snowfall in the low regions are connected with the meridional conversion of the deformation field in the troposphere, in region of which the cold is spread above Caucasus. A similar situation caused the earliest snowfall in Erevan, which occurred on 13 October, 1948. According to many-year data snow cover in Erevan can be formed at the end of December. The case in Armenia pointed out above caused sharp decrease in the temperature of air and strong snowfall. In Erevan for days the temperature was lowered to 18°.

In the territory of Armenian SSR shower precipitation in essence are observed in the spring-summer period and at the same time strongly developed thunderstorm activity occurs. The latter in winter is absent, we do not consider the single thunderstorms, noted during the many-year period of observations.

Thunderstorm season in essence covers period from March through October. The maximum number of days with the thunderstorm is observed in May-June, during July - September occurs slow decrease, and during October the number of days with the thunderstorm insignificant. In November-February the thunderstorms are observed only in the separate anomalous years.

During May-June the greatest frequency of precipitation occurs in second half of day from 13 to 19 h.; it is somewhat less in first half

of night - from 19 to 1 h. During August, on the contrary, the greatest frequency falls on first half of night, comparatively, less than the cases of precipitation occurs in second half of day. The frequency of precipitation is equally small in the remaining time of day.

The distribution of thunderstorms occurs in much the same nature in the course of twenty-four hours. In all months the smallest number of thunderstorms is observed in second half of night; their percentage is very small.

Page 13.

During May shower precipitation and thunderstorms, in essence, begin 15-16 hours, i.e., immediately after the onset of the daily maximum of the temperature of air, when the intensive thermal convection even more greatly increases the moisture lability of invading cold, humid air masses. During June this period is displaced 18 hours, since drier air masses penetrate, while during July and August the greatest frequency of shower precipitation and thunderstorms falls on 18-21 hours. In May-August predominate shower precipitation and thunderstorms of frontal and past-front, connected with cold advection in the region of the meridionally directed trough of northern cold depression, is extended above Caucasus. However, in spite of this, is observed the clearly expressed daily variation of precipitation and thunderstorms.

Complex orographic conditions have a great effect on the nature of rainfall distribution on the territory of Armenian SSR. Average annual amount of precipitation varies over wide limits. In the Araratskoy plain it is equal to 200-300 mm, in the northern regions - to 700 mm, while at the high-mountain station of Aragats 814 mm. It should be pointed out that in the rainfall distribution the vertical zonality does not play the dominant role. A quantity of falling precipitation more greatly depends on the exposure of slopes with respect to the basic directions of the motion of the masses of air.

Upon prevailing west-east transfer to the western slope of the Gegamskyy ridge according to observation of Razdane average annual amount of precipitation is equal to 597 mm (height of site 1766 m). On the eastern slope of the same ridge (in Kamas) the amount of precipitation is equal to 435 mm despite the fact that the latter is located on the higher mark - 1950 m above sea level.

Analogous fact is detected during the comparison of observations at sites of Sisian and Goris. Sisian is found on eastern, leeward slope of the Zangezurskyy ridge at the height of 1614 m above sea level, and Goris - on the western slope of Karabakh upland at the height of 1364 m.

Page 14.

Despite the fact that Goris is located 250 m lower than Sisiana, in Sisiane average annual amount of precipitation is equal to 361 mm,

whereas in Gorise it is equal to 701 mm, i.e., almost two times more.

In the territory of Armenian SSR the greatest amount of precipitation is observed on the northern, windward slope of the Bazumskyy ridge. At the site Kalinin (1500 m abs.) average annual amount of precipitation is equal to 702 mm.

On the mountain mass of Aragats is observed approximately identical rainfall distribution. With exception of high-mountain station, remaining observation sites are located on the delay time to 2000 m above sea level. precipitation at this height reach 600 mm.

The basin of Sevan lake is separated by small amount of precipitation. Here observation sites are located on the height of 1920-1950 m above sea level, and average annual amount of precipitation varies in the limits from 400 to 450 mm.

In the territory of Armenian SSR the aridest place is Araratskaya plain.

As a result of the weak meteorological illumination of the slopes of mountains with the marks more than 2000 m it is impossible to directly calculate the vertical gradients of precipitation. According to available data it is possible to approximately establish order of values of the vertical gradients of annual total precipitation. The greatest gradient of precipitation is observed on the northern slope

of the Bazumskyy ridge. According to the observational data of the sites Stepanavan, Kalinin and Kuybyshev the vertical gradient is approximately 60 mm to 100 m. In the valley of the river of Pambak (according to the data of the sites Kirovakan and Lermontovo) it is equal to approximately 30 mm to 100 m. On the slopes of Aragats mountain the vertical gradient of precipitation is equal to approximately 15 mm on 100 m. Gradient on the northwestern slope of city of Aragats is somewhat more. Also especially separated is the zone in the foot of mountain, turned to the Araratskoy plain, i.e., to aridest terrain. The vertical gradient of precipitation in this zone is great.

Page 15.

The vertical zonality of terrain and latitudinal factor has a basic effect on the condition of the temperature of air.

The highest average annual temperature of air of 13.8° is observed in Megri (691 m of abs.). In the northern part of the republic in the lowest places the average annual temperature of air oscillates about 12°. In the Araratskoy plain it fluctuates between 11-12°. In the high-mountain regions, situated on the height of 2000-2300 m above sea level, the average annual temperature of air oscillates in limits of 2-4° heat, and at the high-mountain station of Aragats it is equal to 2.7° frost, Yeratumbere 2.5° frost. At these stations the average monthly temperature of air is positive only during June - September. The highest average monthly temperature on

the larger part of the territory is observed during August. At the high-mountain station Aragats it is equal to 9.2° heat, in Yeratumbere 8.8° heat.

Lowest average monthly temperatures of air everywhere are observed during January.

In summer time is clearly expressed the vertical zonality of average monthly temperature. On one and the same slopes of mountains the vertical gradient of mean temperature of August is equal to 0.5'-0.8° to 100 m. On the northern slope of the Bazumskyy ridge the vertical gradient around 1.0°, on the southwestern and southeastern slope of Aragats mountain around 0.8° on 100 m. In the winter time the gradients of temperatures sharply decrease, vanishing; frequently gradient becomes negative and inversion is observed. Winter inversions are caused by two reasons: thin winter invasions of cold air, when the thick layer of warm air is retained above it, forming the considerable inversion, which sometimes begins from the height of 2000 m above sea level. Strong cooling by radiation emission in the low terrains is the second reason for the decrease of gradient, in consequence of which here the surface boundary layer becomes colder than on the slopes of mountains, forming ground inversion, which is destroyed in the day time.

Page 16.

The orographic conditions of the territory of Armenia play

considerable role in the development of thunderstorm activity; they affect, also, number of other meteorological factors.

The wind is subjected to a considerably larger effect of orography. The main flows of the masses of air on the earth's surface sharply change their direction in the dependence on the presence of ways, on which they freely can penetrate one region or another. In this case the bending and the flow around ridges occurs. Unconditionally the passing of air through the mountain obstructions occurs, which on their windward side amplifies turbulence and turbulence, and on the lee side during the depression of air foehn effect frequently occurs.

Dynamic turbulence and convection, caused by the dynamic head, is completely different from that, which is caused in the plains conditions.

Since the value of dynamic turbulence and convection, that appear directly in mountain obstruction, until it is difficult to determine, is judged directly by their effect. Separate regions are obliged specifically, to them by very considerable precipitation in mountain obstructions during one and the same process.

Under the conditions of complex orography considerable place occupy the local winds, caused by the presence of the thermally heterogeneous underlying surface. On the latter breezes also depend

on the sharply pronounced mountain-valley winds, and in the basin of Lake Sevan. All these conditions, being superimposed on each other, lead to a sharp difference in the wind conditions in a comparatively small territory.

In connection with the fact that the special work (see present collection), is dedicated to wind conditions, here they have not produced any detailed characteristic of the winds. Let us name only some special features.

In the valleys of mountain rivers the winds in essence are headed along the valley.

Page 17.

As striking example serves the prevailing wind direction in Gukasyane and Leninakan (valley of the river of Akhuryan), in Spitake (river of Pambak), in Dilizhane and Idzhevane (river of Agstev), etc.

Peculiar wind conditions is observed in the basin of Sevan lake.

The wind conditions of the mountain mass of Aragats are also peculiar. At the high-mountain station, located on the height of 3229 m above sea level, prevail the western winds, which in proportion to descent for the southeastern slope of mountain accept northern direction. At Koshabulag station the prevailing direction is north.

Into the river valley it is given, that the masses of air prevail both from the north and from the south and southwest. In Erevan the northern winds occupy the first place on the frequency, the second place divide between themselves the northeastern and southwestern winds. Here the mountain-valley winds strongly develop, which frequently coincide with the prevailing winds, in direction is increased the percentage of their frequency. In Erevan the characteristic feature of summer mountain winds is the fact that they begin considerably earlier than sunset, almost immediately after the onset of the maximum temperature of air. This obviously can be explained by the fact that the thermal convection in the daytime intensely is developed, the ascending currents are amplified and, once in second half of day pressure gradients sharply increase. On the contrary, during the anticyclonic conditions of the weather, when thermal convection is very weak, mountain winds are barely observed.

In the Araratskoy plain at sites Artashat and Arazdayan the winds blow along the river valley Arask.

Thus it is obvious that the wind direction on the earth's surface in the territory of Armenian SSR does not completely characterize the common mass transfer of air.

From everything outlined above it appears, that together with circulation and other factors on a climate of the territory of Armenian SSR an essential effect have the orographic, and also hydrographic conditions.

Page 18.

REFERENCES.

1. **Бельская Н. Н.**—Южные циклоны и условия их перемещения на ЕТС. Тр. ЦИП, вып. 17 (44), 1949.

2. **Зубян Г. Д. и Погосян Х. П.**—Влияние озера Севан на количество осадков, выпадающих в его бассейне. Тр. ВЭНИ АН Арм. ССР, № 1, 1950.

3. **Кирищян Г. О.**—Условия, сопровождающие грозовую и ливневую деятельность в Армении. Тр. ВЭНИ АН Арм. ССР № 1, 1950.

4. **Погосян Х. П.**—Сезонные колебания общей циркуляции атмосферы. Тр. ЦИП, вып. I (28), 1947.

Page 19.

WIND CONDITIONS OF THE TERRITORY OF ARMENIAN SSR.

A. G. Nersesyan [deceased].

The conditions of the wind in the territory of republic is very diverse. In direction and wind speed act many factors, from which mainly are: the seasonal distribution of air pressure, the forms of relief, (direction of river and mountain valleys, the arrangement of crossings, etc.), the height of terrain, the presence of considerable on the area of lake Sevan.

In Armenian SSR as in the mountain country, there are large differences in the heights of separate sites and with respect to this considerable variability in the distribution of air pressure. Average air pressure at lowest station (height of 448 m) is equal to 968 mb. during January and 956 during July, on highest (height of 3228 m) respectively 681 mb. and 687 mb.

From October through April in the Armenian upland is formed the high-pressure area, which is one of the basic factors of the winter conditions of the wind. The region of low pressure, which is one of the basic factors of the summer conditions of wind, is formed in warm half of year (from May through September) in Transcaucasia's south.

Wind direction.

In the territory of Armenian SSR a change in the wind direction carries seasonal nature; however, there are the regions, where the winds of one direction prevails for the course if the entire year.

Pages 20-21.

Pages Missing.

Page 22.

the southeastern part of Transcaucasia, western part of Central Asia and northern part of Iran.

Therefore in the eastern and southeastern part of Armenian SSR in the warm season common wind current has eastern direction - from Caspian Sea. In the basins of the rivers, where the valleys have a direction from northwest to the southeast, the eastern winds differ from initial direction and is accepted southeastern direction (Bazarchay, Gekhi, Kafan). In the region of Gorisa and Verin Khotanan the eastern winds change direction to south.

In Verin Khotanan is the gorge, directed from the north to the south, and the eastern winds prevail with southern flows along the gorge. Martiros lies on the southern slope of the Ayotsdzorskyy ridge. From the north to the south the gorge is passed as the depth of 200 m. For the course of the entire year in Martirose the winds of southern direction along the gorge blow. The valley of the river of

Arpa is directed from the northeast toward the southwest. Throughout entire valley prevails the wind, which blows on the valley from the northeast (Areni, Dzhermuk). At the health resort of Dzhermuk the eastern winds the warm season prevail even through the Kochbekskiy crossing by southeastern flow. The prevailing wind direction is eastern along the Sisianskom crossing at the height of 2348 m in the warm months. Since crossing is opened to the east and to the west, eastern flows from Caspian Sea prevail along the Sisianskiy crossing without the deviation. In the southern part of Armenian SSR in Megri region the valley of the river of Araks is directed from the west to the east. In the warm months here prevail the winds of the eastern direction, which blow on the valley of Araksa. The Nakhichevan' ASSR have same eastern winds, going around the southern extremity of the Zangezurskyy ridge, prevailing by the southeastern flows, which in the warm months are there predominant.

In the cold season, as it was said above, the wind conditions of Armenian SSR depends on the high-pressure area, which is formed in the Armenian upland.

Page 23.

In the northern and center sections of the republic in the cold season the prevailing wind direction is southwestern, while in the southeastern part - northwestern. The southwestern winds, which blow from the center of pressure maximum in the Shirakskoye plateau, differing from the Shirakskyy ridge, with northwestern flows move

along the valley of the river of Akhuryan: (Leninakan, Aragats, rail road of Karmrashen). In the winter months here as in summer, prevail the northern and northwestern winds, which during the rotation of Araks river to the east also change their direction. In the Oktemberyan mass both in summer and in winter, prevail the western winds.

By the direction of river valley is explained the prevailing of the northwestern winds in the region of Artashata, Ararat, Arazdayana.

The winds northern quarter on the western slope of Aragatsa mountain are observed at the heights to 1600 m - 1700 m (Verin Talin). In the higher places out of the basin of river of Akhuryan (at the heights of 2000 m and higher) the winds of southwestern direction in the cold months are retained (Garnovit, Gezaldara). At the heights above 3000 m (Aragats v/g) prevail the winds of western direction.

In Loriyskoy plain (Kalinin) in winter prevail the winds of the southwestern direction, which penetrate from the Karakhachskogo crossing. In the northeastern part of the republic the winds, which blow from the center of pressure maximum, become apparent in Uzunlare, Idzhevane, Dilizhane, Lermontove with the winds of southern and southwestern direction. On entire basin of river Razdan from the high-pressure area the winds they move with southwestern flows, the exception is the Arzni region.

In the basin of Sevan lake in the cold months the winds, which blow from the high-pressure area, penetrate Sevan by the western winds, to the island Sevan - southwestern, in Kamas - western.

On the southeast of republic in Zangezure the winds from the center of pressure maximum penetrate to the open crossings by the western flows (Sisianskiy crossing).

Page 24.

Western flows, after moving the Zangezurskiy ridge, penetrate the eastern regions (Gekhi) of ridge. These flows are deflected by the river valleys, becoming apparent by the northwestern winds (Bazarchay, Sisian, Verin Khotanan, Kafan, Megri).

One should emphasize that the winds of one direction during the year are observed when locality is surrounded by mountains and in any direction passes gorge or the valley. The direction of gorge or valley is the direction of prevailing winds during the year. Such places are on the northeast - (Debedashen, Shnokh, Kokhb, Berd, Aygedzor, Kirovakan), on the southern slope of Ayotsdzorskyy ridge (Martiros). Such winds, are also observed, in the places, which are located under the effect of the crossings (Stepanavan, Mazra), and also with the valley of river Akhuryan and the average current of river Araks.

Daily variation of wind direction.

In many places of Armenian SSR, in the direction of prevailing winds for the course of the entire year, becomes apparent the daily variation, caused first of all by the action of the mountain-valley winds.

For the course of the entire year the mountain-valley winds are observed in the northeastern part of the republic (Shnokh, Kokhb, Uzuntala, Idzhevan, Berd, Aygedzor). Here at night, in the morning and in the evening from the mountains blow the winds of southern (Shnokh, Berd) and southwestern (Kokhb, Aygedzor) direction, and in the daytime hours - the northern and northeastern winds from the valley river Kury.

In the region Kirovakana, on the slopes of the mass of Aragatsa, in the valley Razdan, in the Araratskoy plain, on the slopes of the Gegamskyy ridge and in the basin of the river of Arpa mountain-valley the circulation more strongly becomes apparent in the warm time and is more weak in the cold months of year.

On the southeastern slope of the mass of Aragatsa at night, in the morning and in the evening blow the winds of northern direction from the mountain, and in the warm daytime hours - southern from the valley into the mountain.

Page 25.

On Aragatse v/g ILLEGIBLE LINES.

In Araratskoy plain in the night, morning and evening hours, with exception of June - July, prevail the winds of the northeastern direction, which blow from the mountains, whereas in the daytime hours - southwestern and southern winds, which blow from the valley.

In those places, where the mountain winds move along deep gorges or canyons, where the insolation duration is less, heated by solar rays ceases earlier. In such places mountain winds come into action long before sunset.

In the valley of Arpa mountain winds blow from the mountains in the northeastern direction, and trough - in southwest.

In Martuni in the summer time daily exchange in the.wind direction is produced by the effect of lake (breezes).

In the daytime and in the evening pressure gradient of air is directed from the lake to the land, and in Martuni at this time of day blow the winds from the lake by northern direction. At night and in the morning pressure gradient is directed with the land in the lake and the winds they blow on the river valley by southwestern direction.

In the very a few places is a daily variation in the wind direction only in the cold months. In Dilizhane from October through

February at night, in the morning and in the evening the winds are directed from the valley of the river of Agstev to the mountains. In the daytime hours the southwestern downflows from the vertex of Tezh-Akhmet with warm winds enter valley. In warm half of year here there is no daily variation in the wind direction, only the frequency of the northeastern winds into second half of day increases. There is no daily variation in the wind direction on the open crossings (Sisianskom, Lermontovskom), and also in the open elevated plateaus. There is no daily variation in the wind direction and along the valley river of Akhuryan, on Aragatse rail road, Karmrashene, where during the day the winds always blow in one direction along river valley.

Page 26.

Wind speed.

The distribution of wind speed as direction, is very un-uniform. On the Sisianskom crossing the average annual speed is 7.2 m/s, whereas in the valleys 0.6 m/s (Megri). Wind speed depends on the height and on the openness of place, relief, season, time of day and from the nature of the underlying surface.

It is known that wind speed increases with the height of place. In Erevan, at the height of 910 m the average annual speed of wind us 1.7 m/s, on Aragatse v/g at the height 3228 m speed of 4.6 m/s. But in the places, where the local physicogeographical factors contribute to an increase in wind speed, independent of the height of place wind speed is large. As a good example can serve the wind speed in Yeramtumbere, Sisianskom crossing and Aragatse v/g. Meteorological station on the Sisianskom crossing lies below the weather station of Aragats v/g on 881 m, and in spite of this the wind speed on the Sisianskom crossing is more than wind speed on Aragatse v/g. In 1953 the average wind speed in July on the Sisianskom crossing was 9.3 m/s, and on Aragatse v/g in the same month was equal to 2.0 m/s. In 1953 there were 83 days with the high winds on the Sisianskom crossing, in 1955 - 82, and on Aragatse v/g - 22. The high-mountain station of Eratumbur lower than Aragatsa v/g at 200 m, but also more opened, has

the wind speeds more than at Aragatse v/g.

On the Sisianskom crossing there is high wind speeds for that reason, the crossing is opened from the east and from the west, and from the north and the south the level is closed by mountains.

Table 1. Average annual wind speed in 1959 m/s.

(a) Станции	(b) Высота (м)	(c) Средняя годовая скорость, м/сек.
(1) Арагац в/г	3228	4,5
(2) Ератумбер	3020	5,5
(3) Сисианский перевал	2382	8,3

Key: (a). Stations. (b). Height (m). (c). Average annual speed, m/s. (1). Aragats v/g. (2). Yeratumber. (3). Sisianskiy crossing.

Page 27.

From the eastern side the crossing is turned to the basin of the river Vorotan, where the winters are cold, summer moderately warm; from the west the crossing is turned to the basin of river Nakhichevan'-chai, where the summer is hot, winter warm. Between the western and eastern sides are obtained the large differences in the temperature of air, consequently large differences also in the air pressure, which contributes to the intensification of the wind on the Sisianskom crossing. On Semyonovskiy and Lermontovskom crossings, average in the year wind speed in comparison with the Sisianskim crossing is less (on Semyonovskiy - 3.3 m/s, on Lermontovskom - 2.6 m/s). Here such a considerable differences in the pressure from the different sides of crossing is not created.

Mazrinskaya plain is located on the western side of Zodskogo crossing. On the crossing there is a col and for the course of the whole year the winds are directed through the crossing from the east in the Mazrinskuyu plain. The eastern winds strong and in daily

variation the minimum of calms is observed, when there is the maximum of the frequency of the eastern winds. This is well noticeable into cold half of the year, when the frequency of the eastern winds in the daytime hours decreases; the number of calms increases in the same hours. The number of calms decreases in night and morning hours in connection with an increase in the eastern winds. The frequency of the eastern winds is equally great in the daytime and at night in the warm months, in consequence of which the windy weather in summer is held around the clock. In the southern part Loriyskoy plain in the winter months the highest winds are southwestern, which blow from the high-pressure area through the Karakhachskiy crossing.

The water underlying surface in view of the decrease of friction contributes to an increase in wind speed. On Sevan island at the height of 1918 m the average annual speed of 4.6 m/s, i.e., the same, as that on Aragatse v/g at the height of 3228 m.

The protection of place by mountains also exerts great effect on the speed and wind direction. As an example can serve data of the health resort Dzhermuk. The health resort Dzhermuk is located in the wide plateau at the height of 2080 m.

Page 28.

From three sides health resort is shielded by mountains, especially from the eastern side, where in health resort it directly passes the high wall of western slope of the Zangezurskyy ridge which is covered

with forest. Zangezurskiy ridge is passed along the way of the eastern winds and therefore the winds from the eastern direction is very small at the health resort of Dzhermuk.

At the end of August of 1955 for servicing the aviation was opened the 2nd station on the other bank of Arpa river. At the new place from the eastern side the height of mountain is less by 350 m. Parallel observations during several months of 1955 and in 1956 show that the frequency of the eastern winds in the Dzhermukskyy airport is greater. The number of cases of the winds of eastern direction at both stations in 1956 is given below.

Despite the fact that Dzhermuk health resort lies on a high altitude (2800 m), wind speed is small due to the protection by mountains. High winds are also small. When on the western more open slope of Vardenisskyy ridge 35 days of in the year (Yanykh) with high winds, at Dzhermuke (health resort) in the same year, 3 days. In the Dzhermukskyy airport wind speed is greater than at the health resort; there is an especially large difference in the summer months, when the eastern winds it is more. The difference in wind speed is less in the cold months.

Table 2. Number of cases of the eastern winds for 1956.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
(a) Джермук, курорт	0	0	3	1	1	4	8	3	1	0	0	3
(b) Джермук, аэропорт	10	5	28	18	9	26	33	22	12	5	8	8

Key: (a). Dzhermuk, health resort. (b). Dzhermuk, airport.

Table 3. Average monthly wind speed for 1956.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	(a) год
(b) Джермук, курорт	1.7	1,0	1,4	1,4	1,6	2,3	2,4	1,8	2,1	1,6	1,6	1,1	1,7
(c) Джермук, аэропорт	1,0	0,8	2,4	1,8	2,4	3,1	4,2	3,7	3,1	1,8	1,0	1,2	2,2

Key: (a). year. (b). Dzhermuk, health resort. (c). Dzhermuk, airport.

Page 29.

The nature of the valley has a great effect on the wind speed. If valley from three sides is closed by mountains and begins directly from the bottom of mountain, the wind speeds in such valleys are small. In those valleys, which are opened from two opposite sides, wind speed large. Wind direction along the valley is retained in both cases. As an example it is possible to cite weather data on the valley of the river Gekhi (inflow of Vokhchi), where the valley is closed from three sides and begins directly from the bottom) (Zangezura) mountain and river valley is given, opened from two opposite sides and closed from opposite sides. The valley of the river of Gekhi is closed from the western side with the eastern slope of the Zangezurskyy ridge; valley begins here. From the northern side the left bank is closed with the spurs of the Bargushatskyy ridge, which descends to the valley by the steep, rocky slope, which is covered with bushes. From the southern side are passed the spurs of the Zangezurskyy ridge, which is covered with forest. Valley has a direction from west to east with the width of 800 m, depth of 500-700 m. Valley given has a direction from the north to the south. In the

western side in the right-bank part rises the Egvardskoye plateau descending to the river by the flat slope, covered with artificial forest. From the eastern side very steeply rises the Kanakerskoye plateau. Wind speeds are large in the gorge directly in river, to which the nature of the valley of the river from two opposite sides open with the current contributes. In the adjacent plateaus there is also high wind speeds. In the open plateau wind speed is greater; it is comparatively less in the Kanakerskoye plateau, since from its eastern side is passed the Gegamskiy ridge with a height of more than 3000 m. Below are given the average monthly wind speeds, direction of prevailing winds and number of days with the high winds according to the simultaneous observations in Arzni and Gekhi from May through December 1951 (on Arzni given from May).

Page 30.

Despite the fact that Gekhi lies above Arzni and wind speed there must be more, in view of the nature of valley in Gekhi wind speed is less than in Arzni.

Daily variation of wind speed.

In the daily variation maximum wind speed falls on warm half of day, and the minimum - to the early morning and for night hours.

In those regions, where in the summer is strongly developed the crucible trough circulation, the maximum wind speeds are observed in

the warm hours of day. In the places, where the narrow gorge is opened to wide strong heated valley, the maximum of wind speed falls in the hours from 19 through 01 hours. As an example it is possible to cite data of Erevan agrometeorological station.

Table 4. Average monthly speed of wind (m/s).

(a) Станции	(b) Высота (м)	(c) Май	(d) Июнь	(e) Июль	(f) Август	(g) Сентябрь	(h) Октябрь	(i) Ноябрь	(j) Декабрь
(1) Гехи	1760	1,5	1.6	1,7	1,8	2,1	2,4	1,6	1,4
(2) Арзни	1282	1,2	2,8	4,2	4,2	3,0	1,8	1,5	1,9

Key: (a). Stations. (b). Height (m). (c). May. (d). June. (e). July. (f). August. (g). September. (h). October. (i). November. (j). December. (1). Gekhi. (2). Arzni.

Table 5. Number of days with the high winds.

(a) Станции	(b) Высота (м)	(c) Май	(d) Июнь	(e) Июль	(f) Август	(g) Сентябрь	(h) Октябрь	(i) Ноябрь	(j) Декабрь
(1) Гехи	1760	0	0	0	0	0	0	0	0
(2) Арзни	1282	1	3	11	10	8	0	0	0

Key: (a). Stations. (b). Height (m). (c). May. (d). June. (e). July. (f). August. (g). September. (h). October. (i). November. (j). December. (1). Gekhi. (2). Arzni.

Page 31.

Along entire gorge, where river Razdan flows, in the summer months the high mountain winds blow. In Shaumyana region, where agrometeorological station is located, these winds are especially strong and prolonged. Evidently to this contributes the fact that Shaumyana region is located between the valleys of two rivers. Below are given the average wind speed with the current of river Razdan for July, when there are maximum wind speeds.

From June through September in Shaumyana region from 19 hours the high winds with the speed of 15 m/s and more, which blow to midnight, begins.

Table 6. Average monthly wind speed in July 1956.

(a) Станции	(b) Форма рельефа	(c) Высота (м)	(d) Средняя месячная скорость ветра м/сек.	(e) Число дней с сильными ветрами за июль 1956 г.
(1) Арзни курорт	(2) Дно ущелья	1282	4,6	14
(3) Арзни плато	(4) Открытое плато	1350	3,0	14
(5) Егвард	(6) Плато	1321	6,1	12
(7) Ереван город	(8) Открытый склон	1213	4,4	17
(9) Ереван агромет	(10) Равнина	942	6,8	25

Key: (a). Stations. (b). Form of relief. (c). Height (m). (d). Average monthly speed of wind m/s. (e). Number of days with the high winds in July 1956. (1). Arzni health resort. (2). Bottom of gorge. (3). Arzni plateau. (4). open plateau. (5). Yegvard. (6). Plateaus. (7). Erevan city. (8). open slope. (9). Erevan agrometerological station. (10). Plain.

Table 7. Average monthly wind speed during the periods in July 1956.

(a) Станции	(b) 1 час	(c) 7 часов	13 часов (c)	19 часов (c)
(1) Арзни курорт	4,4	2,0	3,2	9,1
(2) Арзни плато	3,1	1,3	2,2	5,1
(3) Егвард	5,2	5,3	2,9	11,1
(4) Ереван город	4,6	0,5	1,3	11,3
(5) Ереван агромет.	9,7	2,0	2,2	13,4

Key: (a). Stations. (b). 1 hour. (c). ... hours. (1). Arzni health resort. (2). Arzni plateau. (3). Yegvard. (4). Erevan city. (5). Erevan agrometerological station.

Page 32.

The maximums of wind speed for 19 hours are observed in the warm months in the basin of Razdan (Razdan), in the Shirakskoy plain. Here there is no daily variation in the wind direction, and its intensification in the post-meridian hours and the maintaining of the high speeds for 19 hours is explained by the intensification of turbulent processes.

Wind speed on the rhumbs.

In many places strongest are winds of the prevailing directions. On northwest, in the beginning of the course of Akhuryan river, in the Shirakskoy plain in terms of maximum speeds the prevailing northern winds differ. The winds of southeastern direction are light breezes in this region. In the Loriyskoy plain the highest winds are the winds of the prevailing direction - southwestern, especially in the cold months; weakest - southeastern. In Dilizhane also strongest are prevailing winds: in the winter months of southern direction, in the

warm months (from April through September) - northeastern.

In Idzhevane the highest winds are in summer northern, in the winter months - southwestern and southern. In Spitake in the winter months the maximum speeds are characterized by the winds of the prevailing directions - western and southwestern; in the warm months - northeastern. On Aragatse v/g in the course of the whole year the maximum speeds are characterized by the winds of northwestern and western direction, i.e., also the prevailing winds are strongest. The light breezes of northeastern direction. On the southeastern slope) of Aragats (Koshabulakh mountain in the cold months strongest are the winds of western direction, and from June to August-northern direction. The eastern winds are characterized by minimum speeds.

Page 33.

On Semyonovskiy crossing from October through May the highest winds are the winds southwestern, in the warm months (from June through September) the maximum speeds have winds of western direction. In Sevan and in Sevan peninsula in the cold months the prevailing winds are southwest. The same winds have maximum speed. On southern coast of lake Sevan as everywhere, the prevailing winds are strongest: in the cold months - southwestern and southern, in the warm months - northeast. In the Mazrinskoy plain for the whole course of the year the strongest are the winds of eastern direction.

In Sisiane the prevailing winds are also high winds. In the

winter months the highest winds are northwestern and are western, in the warm months - eastern and southeastern. The winds of southern direction are weakest.

In the extreme south Megri region the high winds do not coincide with the direction of prevailing winds. Here the highest winds are the winds southern quarter: southeastern and southern.

Annual variation of wind speed.

The annual variation of wind speed is not identical everywhere. Where in the winter months the frequency of the winds of western and southwestern direction large, annual maximum of speed falls in the winter months.

The winds, which blow from the high-pressure areas in the western and southwestern direction, have high speeds in comparison with other directions.

Page 34.

The annual variation of speed of the wind of two adjacent stations can serve as confirmation: Dzhadzhur on the eastern side of tunnel and Dzhadzhur on the western side. The length of tunnel is 7 km. The prevailing wind direction is western on the eastern side in the winter months. The annual maximum of wind speed is in winter (average in January 4.4 m/s, August 3.7 m/s). On the western side for the whole

course of the year the prevailing direction of eastern and annual maximum of wind speed is in summer (average in January 1.7, August 6.4 m/s).

The maximum of wind speed in the winter months is observed in the Loriyskoy plain, and also with the current of Pambaka to the turn) to north (Spitak river, with the current of Getika (Krasnosel'sk) and on the coast of Sevan lake (Sevan, island Sevan, Martuni), on all crossings, in the high-mountain zone on the southern slope of the Ayotsdzorskyy ridge.

In those regions, where the stagnation of cold masses of air in winter occurs due to the relief, although there are the western winds, in winter there is the minimum of wind speed. In the places, where the mountain-valley winds blow and in summer the speed of mountain winds is amplified, the maximum of the speed in the annual variation falls on the summer months, and the minimum in winter.

To such places with the maximum in the summer months relate: the basin of Akhuryan river, the Western slope of Aragatsa, Verin Talin, Araratskaya plain, middle and lower parts of the basin of Agstev river, basins of rivers Arpa, Vorotan, Vokhchi. In the eastern and southeastern part of the republic, where the winds of eastern or southeastern direction prevail in the summer, the maximum wind speed is noted in the summer. The maximum of wind speed in the summer months is also in the southeastern corner of Sevan - at lake of

Mazrinskoy plain. In some places maximum wind speed is observed in spring (in the region of Kamas, and also on the southeastern slope of the mountain of Aragats - in Koshabulakhe).

Page 35.

Mountain and valley winds.

In Araratskoy plain for the course of the whole year the mountain and valley winds blow, which are amplified in the period from June through September. The mountain-valley winds have well expressed daily variation. For the entire course of the year, in the daytime hours the blows the southwest and southern winds, and in night hours from the mountains into the valleys - north. Before a change in the wind direction for a long time the calm is established. During January the transition of the mountain north-northeastern wind to trough southwest occurs at 10 A.M. The subsequent transition of trough southwest to mountain north-northeast occurs at 20 hours.

From February through May the transition of north-northeastern direction to southwest begins at 8 A.M., reverse transition occurs in the time interval from 17 to 18 hours.

During June - July and partially during August, because of early sunrise and early heating of soil and air, the transition of the wind of north-northeastern direction to southwest begins earlier (7 hours). Valley wind in this case is held to 17 hours, after which the

direction to north-northeast is changed. But cases occur, when valley winds blow to 13 hours and after their certain calm change mountain winds. During September the transition of the wind of north-northeastern direction to southwest occurs 8 hours and is held to 16 hours, after which 17 hours the reverse transition of the wind occurs.

Page 36.

During October, November and December the transition of the wind of north-northeastern direction to southwest begins at 9 A.M.; in this case the valley winds are held to 18 hours. The mountain-valley winds, which blow in the Araratskoy plain, differ from the mountain-valley winds cf other regions in terms of the fact that here the exchange of the trough southwestern winds to mountain north-northeast occurs early, even at sunset, whereas in other places valley winds blow during only day up to sunset. Evidently, the narrow gorge of river is the reason for the early transition of valley winds to the mountain. Even solar rays cease to fall long before sunset into the deep gorge, in consequence of which the large differences in the temperature and in the air pressure appear early.

Mountain winds reach the maximum speed 18-19 hours, they blow at a rate of 20 and more m/s. Pressure gradient of air between the valleys and the mountain slopes remains considerable and after sunset. Pressure gradient of air between the valleys and the mountain slopes decreases in proportion to cooling soil and surface boundary layer and

wind speed respectively decreases. Before sunrise at the moment of the minimum of the temperature of air, the speed of mountain winds reaches to 1 m/s.

Beginning from June the mountain-valley circulation is amplified, the maximum speeds are observed during July. During September the intensity of the mountain-valley winds is gradually decreased, and at the end of October in the post-meridian hours the calm prevails. In the summer months with the entry of the thoroughly heated dry tropical masses of air, when simultaneously are heated the slopes and valleys, mountain-valley winds cease. During such days daily temperature range reaches the minimum.

Page 37.

High winds.

For the development of regions with the high winds with a speed of 15 m/s and more, and also the annual variation of days with the high winds is processed by direct calculation the number of days with the high winds for all stations during the identical period of the observations: from 1936 through 1960 yr. Only on two stations - Sisianskiy crossing Erevan, agro- are processed observation during the period of 1951-1960 yr., since on these stations there is data only since 1951.

The table of the number of days with the high winds is given below.

From the table it is evident that most all days with the high winds on Sisianskom crossing (85.6 in the year).

Table 8. Average number of days with the high winds.

(a) Станции	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	(b) год
(1) Амасия	0,7	1,6	1,6	1,1	0,4	0,6	0,7	0,8	0,4	0,5	0,4	0,2	9,0
(2) Ленинакан	1,2	1,7	3,5	2,8	2,3	1,9	2,0	2,9	1,2	0,9	0,4	0,9	21,7
(3) Калинино	5,7	4,8	3,2	1,0	0,7	0,1	0,04	0,1	0,1	1,0	1,6	4,0	22,3
(4) Ш н о х	0,6	0,8	0,5	0,6	0,4	0,2	0,2	0,3	0,04	0.04	0,2	0,4	4,3
(5) Б е р д	0,2	0,1	0,0	0,0	0,1	0,05	0,0	0,0	0,0	0,04	0,1	0,05	0,6
(6) Кировакан	2,4	2,1	2,0	0,9	0,7	0,3	0,1	0,3	0,4	0,7	1,0	1,0	11,9
(7) Апаран	0,4	0,8	0,8	0,6	1,1	0,5	0.3	0,2	0,4	0,3	0,4	0,4	6,2
(8) Арагац в г	4,9	4,7	3,8	2,4	1,3	0,6	0,2	0,3	0,8	2,2	2,7	3,6	27,5
Остров (9) Севан	4,4	3,8	3,1	1,7	1,6	0,7	0,7	0,9	1,0	2,1	2,1	3,7	25,8
Севан (9)	3,4	4,1	4 5	2,6	2,0	1,2	0,7	0,8	1,4	2,3	2,1	3,1	28,2
(10) Камо	3,8	3,9	3,6	2,2	1,5	0,8	0,2	0,3	1,1	2,0	1,9	2,9	24,2
(11) Мазра	1,5	1,2	1,8	1,8	1,6	1,5	2,1	1,7	1,0	0,7	0,8	0,8	16,5
(12) Яных	4,3	4,0	4,1	2,8	2,3	1,0	0,4	0,7	1,4	2,8	2,7	3,0	29,5
(13) Шоржа	2,0	1,3	0,9	0,6	0,4	0,6	0.2	0,4	0,4	0,9	1,0	1,2	9,9
(14) Октемберян	0,4	0,5	1,0	0,9	1,9	1,4	1,2	1,2	0,7	0,9	0,2	0,2	10,5
(15) Ереван	0,7	1,2	2,4	2,6	3,2	5,4	8,1	6,2	3,1	0,8	0,5	0,4	34,6
(16) Ереван-агрометстанция	0,2	0,9	2,8	3,8	3,3	11,3	13,7	16,0	7,7	0,6	0,3	0,2	66,8
(17) Сисианский перевал	9,9	11,0	11,2	8,8	6,2	4,8	5,0	4,0	3,9	5,1	6,8	8,9	85,6
(18) Сисиан	0,4	0,5	0,4	0,5	0,6	0,5	0,4	0,3	0,3	0,4	0,2	0,2	4,7
(19) Кафан	0,6	0,7	0,3	0,4	0,1	0,1	0,2	0,0	0,1	0,04	0,1	0,1	2,7

Key: (a). Stations. (b). year. (1). Amasiya. (2). Leninakan. (3). Kalinin. (4). Shnokh. (5). Berd. (6). Kirovakan. (7). Aparan. (8). Aragats v/g island. (9). Sevan. (10). Kama. (11). Mazar. (12). Yanykh. (13). Shorzha. (14). Oktemberyan. (15). Erevan. (16). Erevan-argometerological staiton. (17). Sisianskiy crossing. (18). Sisian. (19). Kafan.

Page 38.

There are also many days with the high winds in the district of the city of Erevan. The number of days with the high winds in the closed mountain foundation areas (Sisian), in the forest zone (Berd) is small. The high winds appear, in essence, with the passage of cold fronts and cyclones. In the annual variation in the majority of regions the greatest number of days with the high winds falls on the winter months, which is connected with development at this time of the

year of cyclonic activity.

In the summer months the maximum number of days with the high winds is there, where mountain-valley circulation is observed. The greatest difference in the number of days with the high winds (in the month) for the course of the entire year occurs in) Parakara (city of Erevan) region, where during July the average number of days with high winds is 24.2, and during November 0.0. On the Sisianskom crossing this difference is equal to 10.7, in the Egvardskoye plateau 8.2. The smallest differences in the limits from 0.2 to 0.6 occur: in Megri (0.2), Sisian, Berd, Akhta (0.3), Spitak, Kokhb, Dilizhan, Idzhevan (0.6).

Wind-power resources of Armenia.

The use of cheap energy of the wind in the national economy, especially in the agriculture, has high value. For the development of wind-power service lives according to the republic the probabilities of wind speeds on the gradations are calculated, according to those more frequent within each 1, 2, 3, 4 hours in observations for 24 stations during the period of 1947-1958 yr. and according to the four-urgent observations for 41 station during the period of 1936-1957 yr. The obtained probabilities of wind speeds on the gradations according to the more frequent and four-urgent observations were obtained very close (on the average with difference 1 and 2%).

Page 39.

This shows that the climatic periods completely reflect data in 24 hours. Also the average monthly and average annual wind speeds are calculated. According to the data of L. Ye. Anapolskoy, where average annual speeds of wind is 5 m/s, wind motor D-18 gives 50000 ehf of electric power per annum.

Obtained by us data show that almost half of all stations examined have average annual wind speeds from 1 to 2 m/s. This, in essence, in forest regions even at the heights are more than 2000 m, to this is still added the closed nature of locality by mountains, and the closed plains. In the forest zone and in the closed plains is obtained the greatest probability of wind speed in the gradation 0-2 m/s.

Places with average annual speeds of from 2 to 3 m/s is less than from 1 to 2 m/s. In essence this closed mountain basins, plateau, slopes of Aragatsa are above 1600 m, Loriyskaya plain, crossings Semyonovskiy and Lermontovskiy.

Table 9. Probability of the cases of speed of wind (%%) according to the gradations.

(a) Станции	(b) Форма рельефа	0—2	3—5	6—10	11—16	16—20	21--25	24—30	31--35	36--40
				(1) Январь						
(2) Кирова-кан	(3) пологий склон	62,4	27,0	8,1	1,6	0,5				
(4) Октем-берян	(5) равнина	76,5	16,6	4,8	1,3	0,6	0,2			
				(6) Июль						
(2) Кирова-кан	(3) пологий склон	75,3	23,8	0,8	0,1	0,04				
(4) Октем-берян	(5) равнина	62,8	27,6	8,5	0,9	0,2				

Key: (a). Stations. (b). Form of relief. (1). January. (2). Kirovakan. (3). flat slope. (4). Oktemberyai. (5). plain. (6). July.

Page 40.

Places with average annual speeds from 3 to 4 m/s are to the northwest on the headwaters of river of Akhuryan, on the Dzhadzhurskom crossing, south of Leninakan on Akhuryana coast, in the basin of lake Sevan (besides the closed basins and Mazrinskoy plain), in Erevan in Parakara region.

Table 10. Probability of the cases of speed of wind (%%) according to the gradations.

(a) Станции	(b) Форма рельефа	0—2	3—5	6—10	11—15	16—20
		(1) Январь				
(2) Камо	(3) Закрытая котловина	52,4	27,4	14,5	4,0	1,7
(4) Апаран	(5) Равнина	50,4	32,1	15,0	2,0	0,5
		(6) Июль				
Камо (2)	Закрытая котловина (3)	54,6	31,4	3,7	0,2	0,1
Апаран (4)	Равнина (5)	52,2	37,4	9,2	1,2	0,02

Key: (a). Stations. (b). Form of relief. (1). January. (2). Kama. (3). Closed basin. (4). Aparan. (5). Plain. (6). July.

Table 11. Probability of the cases of speed of wind (%%) according to the gradations.

(a) Станции	(b) Форма рельефа	0—2	3—5	6—10	11—15	16—20
		(1) Январь				
(2) Яных	(3) Склон	33,9	34,6	22,0	7,1	2,4
(4) Шоржа	(5) Прибрежье	45,7	35,9	14,8	2,5	1,1
		(6) Июль				
Яных (2)	Склон (3)	43,2	41,8	14,6	0,4	0,04
Шоржа (4)	Прибрежье (5)	49,1	40,5	10,2	0,1	0,1

Key: (a). Stations. (b). Form of relief. (1). January. (2). Yanykh. (3). Slope. (4). Shorzha. (5). Shore. (6). July.

Page 41.

Places with average annual speeds of 4-5 m/s little. These are separate places in the basin of lake Sevan (island) and are not entirely open high-mountain zone.

On the island and on Aragatse is considerable the frequency of wind speed in the gradation 6-10 m/s in the winter months. High average annual speeds (7.2 m/s) are observed on the crossings of higher than 2000 m of the type Sisianskogo.

Average annual speeds, of course, are not entirely characteristic for the development of the sites of installation of wind motors during the use of energy of the wind. In the republic the places, where wind speed would be evenly distributed for the course of the entire year, are very small. Due to the form of relief in the closed basins,

plains, plateau in the winter months occurs the accumulation and stagnation of cold masses of air and the calm is established, and in summer speeds are greater. In this case due to the winter calms the average annual speeds are insignificant. There are the places, where wind speed in the summer months is more than winter, where the average monthly of summer months are more than 3 m/s (useful speeds for the wind motors).

Table 12. Probability of the cases of speed of wind (%%) according to the gradations.

(a) Станции	(b) Форма рельефа	0,2	3—5	6—10	11—15	16—20	21—25
			(1) Январь				
(2) Остров Севан	(3) Остров	30,3	36,2	26,3	5,8	1,4	0,04
(4) Арагац в/г	(5) Склон	28,5	33,1	26,6	7,9	2,6	0,7
			(6) Июль				
Остров Севан (2)	Остров (3)	41,7	40,7	16,7	0,8	0,1	
Арагац в/г (4)	Склон (5)	59,3	35,1	5,3	0,3	0,05	

Key: (a). Stations. (b). Form of relief. (1). January. (2). Sevan island. (3). Island. (4). Aragats v/g. (5). Slope. (6). July.

Page 42.

Such places include: in the northwestern part of the territory Amasii region, Shirakskaya plain with the northwestern slope of the mass of Aragatsa (Artik), Egvardskoye plateau; in Araratskoy plain Erevan (region of Parakara) and southeastern part; in the basin of lake Sevan-Mazrinskaya plain; in the basin Razdana - Fontan and Razdan; with the average current of Arpa - region of Areni; in Zangezure - the region of Sisiana.

To the places, where in the winter months of wind speed is more than in summer (average monthly more than 3 m/s). Relate: Loriyskaya plain, South and East coast of Sevan lake, region Krasnosel'sk and Lermontovskiy crossing.

There are the places, where for the course of the entire year the average monthly wind speeds are more than 3 m/s, and wind motors can continuously act. Such places include: the crossings of the type of Sisianskogo, in the basin of Sevan lake of region of Sevan-island, place with lower current river Akhuryan (Karmrashen, Aragats, rail road).

For the complete illumination of regions with respect to the use of energy of the wind are necessary other data about the duration of the operating speeds of the wind.

Table 13. Duration of the operating speeds of the wind in the hours in the year.

(a)Станции	>3	>4	>5	>6	>7	>8	>9	>10	>11	>12	>13	>14
(1)Джаджур ж/д	2785	2357	2106	1396	1111	836	588	482	313	309	197	183
(2)Арагац ж/д	3507	1966	1592	724	522	180	127	79	30	29	17	17
(3)Арагац в/г	4680	3153	2519	1605	1326	842	676	318	304	270	179	138
(4)Севан ГМС	3860	2352	1643	755	569	314	266	149	114	114	94	94
(5)Шоржа	3758	1917	1629	620	573	178	159	54	35	34	7	7
(6)Яных	4156	2629	2457	1292	1191	617	586	288	284	284	184	183
(7)Сисианский перевал	6683	5880	4966	4300	3434	2804	2099	1644	832	828	439	439

Key: (a). Stations. (1). Dzhadzhur rail road. (2). Aragats rail road. (3). Aragats v/g. (4). Sevan GMS. (5). Shrozha. (6). Yanykh. (7). Sisianskiy crossing.

Page 43.

Aragats station high-mountain is not entirely characteristic for the high-mountain zone. The place for station from the eastern and northeastern side is strongly shielded by Gel'ziarat mountain, from the northern side by the vertex of Aragatsa. The stations of Aragats v/g the wind speed must be more at the height of 3228 m.

REFERENCES.

1. Анапольская Л. Е.—Ветровой режим водохранилищ степного района Европейской территории СССР. Гидрометиздат, Л., 1956 г.
2. Анапольская Л. Е.—Ветроэнергетические ресурсы. Климатические ресурсы центральных областей Европейской части СССР и использование их в сельскохозяйственном производстве. Гидрометиздат, 1956 г.
3. Воронцов П. А.—Схема построения бризовых ветров в районе Черного моря. Мет. гидр. 1948 г. № 4.
4. Гольцберг И. А.—Климатическое описание с учетом требования сельскохозяйственного производства. Гидрометиздат, 1956 г.
5. Казаков Л. А.—О горно-долинной циркуляции в Средней Азии, 1953 г.
6. Климатологический справочник—По Армянской ССР, вып. 16, Гидрометиздат, 1949 г.
7. Малик С. А.—Синоптические условия сильных ветров. Мет. и гидрол., 1940 г.
8. Нерсесян А. Г.—Климат Еревана. Гидрометиздат, 1950 г.
9. Селезнева Е. С.—Местные периодические ветры в горах. АН СССР, 1939 г., № 4—5.
10. Сухишвили Э. В.—Ветроэнергетические ресурсы Грузии. Труды Тбилисского научно-исследовательского гидрометеорологического института. Гидрометиздат, 1959 г.
11. Хргиан А. Х.—Аэрологическое исследование горно-долинных ветров. Труды ЦАО, вып. 2, 1947 г.
12. Цомая Т. И.—Фены Рионской долины.

Page 44.

HEAT BALANCE OF LAKE SEVAN.

M. M. Aynbund.

By the practical problem of the investigations of heat balance of lake Sevan is the determination of the value of evaporation method having the best physical substantiation. The first heat balance of lake Sevan was comprised by V. K. Davydov.

In recent years the systematic bases of the calculation of separate components of heat balance were in essence developed by the expedition of GGO [12]; however, the heat balance itself was not comprised then. The estimation of the heat balance of lake is carried out also by A. M. Mkhitaryan at the institute of the water problems AN Armenian SSR (IVP).

Is at present sufficient material of the observations, including such, which the previous authors did not have available, which makes it possible to evaluate the existing procedure of calculation of separate hydrometeorological elements, and in the hotel cases and to refine it, was accumulated. This gives the possibility to calculate the components of the heat balance of lake under the contemporary conditions and on the basis of the comprised heat balance to determine

the value of evaporation. The study of these problems composes the content of work.

1. Equation of the heat balance of Sevan lake.

The equation of heat balance can be comprised for different volumetric sections and surfaces in the external geographical shell.

Page 45.

The ratios, which characterize conditions in the vertical column or in the active layer, connected with the natural underlying surface, are at present the most common forms of equation. In certain cases, when the heat balance of the limited basin, which does not have large natural inflow and outflow, is examined, for example Lake Sevan, it is expedient to record the equation of heat balance for the water mass as a whole. This form makes it possible to more simply use it for the solution of some practical problems. Thus, under the conditions Lake Sevan the expression of heat balance in this form proved to be most useful during the composition of the monthly and of the annual heat balance of the individual parts of the lake and the study of heat exchange between them.

Incidentally, in contrast to the previous authors, who examined lake as a whole, is here examined also the Small and Large Sevan, separately, which made it possible to reveal some special features in the heat balance of these parts of the lake.

The equation of the heat balance of lake Sevan taking into account changes in the volume of its water mass can be written in the form:

$$R=LE+P+B+B_{r}+B_{n}+B_{c}, \qquad (1)$$

where R - radiation balance, LE - heat expenditures for evaporation, P - heat expenditure for the turbulent heat exchange of water surface with the atmosphere, B - change in the enthalpy of water mass in time τ, for which the balance is comprised, B_{r} - heat exchange with the soil, B_{n} - admission of heat with the inflows, B_{c} - heat consumption, caused by the decrease of a volume of water mass due to the runoff through the water-engineering constructions.

In the examination of the heat balance of Small and Large Sevan, separately into the right side of equation (1), in principle, must be introduced one additional component - advection (F), caused by heat exchange between the individual parts of lake. It will be shown below that in the specific period this component has value.

Page 46.

The estimation of the least considerable components of heat balance showed that the admission of heat with the surface water in the year does not exceed 6×10^{12} kcal, and heat consumption with the faults through the water-engineering constructions is $13\text{-}14\times10^{12}$ kcal.

Heat exchange with the soil at Lake Sevan has already been

investigated [12], moreover it is established that even in the coastal zone with a depth of up to 1.5 m it does not exceed 5% of radiation balance. Since the intensity of heat exchange with the soil rapidly decreases with an increase in the depth, then as a whole for the lake, where the area of coastal zone with a depth of up to 1.5 m does not comprise more than 1% of entire area, it cannot be practically use.

Thus, the total annual heat losses due to the components of heat balance examined cannot exceed $7\text{-}8\times10^{12}$ kcal (less than 1% annual radiation balance).

The heat balance of lake is examined in the last decade (1951-60 yrs.), moreover for calculating its separate components are utilized data of the following observations: at the meteorological stations, located in the basin of lake, not far from coast feature; at coast meteorological posts near the shoreline, where incidentally, a certain time were conducted the more frequent observations; actinometric in Sevan peninsula and in Martuni; actinometric and meteorological at the floating station; hydrometeorological on the hydrological vertical lines in the open lake. All these observations were fulfilled using the procedure, regulated by the manuals accepted in the system GUGMS [Main Administration of Hydrometeorological Service]. Data of some special observations, carried out both during the decade indicated, and subsequently in 1961, were also used. The arrangement of observation points in the basin of lake and on its water area is shown in Fig. 1.

Page 47.

2. Calculation of temperature, humidity of air and wind speed above Lake. Sevan.

Before passing to the examination of fundamental component of heat balance, it is necessary to dwell on the question about the calculation of temperature, humidity of air and wind speed above the water surface and the accuracy of this calculation. This has vital importance for the definition of such components of heat balance as evaporation and turbulent heat exchange. The materials of the observations of the last years and first line of 4 observations at standard time at coast posts and at the floating station, which functioned in 1960-61 yr., this provided very interesting material.

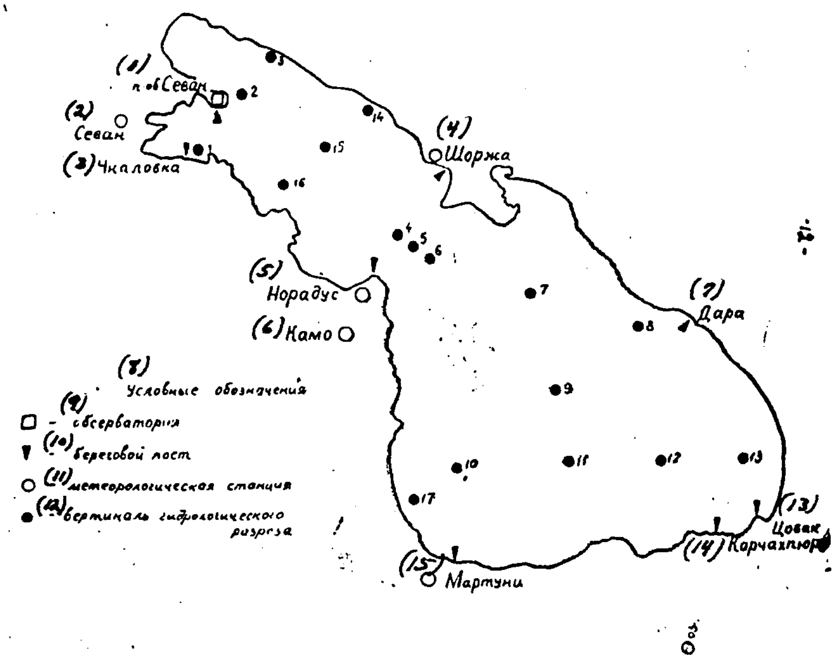

Fig. 1. - the diagram of the positioning of the points of stationary observations at Lake Sevan.

Key: (1). point on Sevan. (2). Sevan. (3). Chialovka. (4). Shorzha. (5). Noradus. (6). Kama. (7). Dara. (8). Conventional designations. (9). observatory. (10). costal post. (11). meteorological station. (12). vertical line hydrological of section. (13). Tsovak. (14). Karchakhpyura. (15). Martuni.

Page 48.

a) the temperature of air above Lake Sevan (Θ_B) by the method of GGO [12] is determined with the aid of the formula

$$\Theta_B = \Theta + (\Theta_W - \Theta) \cdot F_\Theta, \qquad (2)$$

where Θ - temperature of air above the land

Θ_W - temperature of the surface of the water

F_Θ - function, whose values are determined by the significant dimensions of basin and by turbulence characteristics.

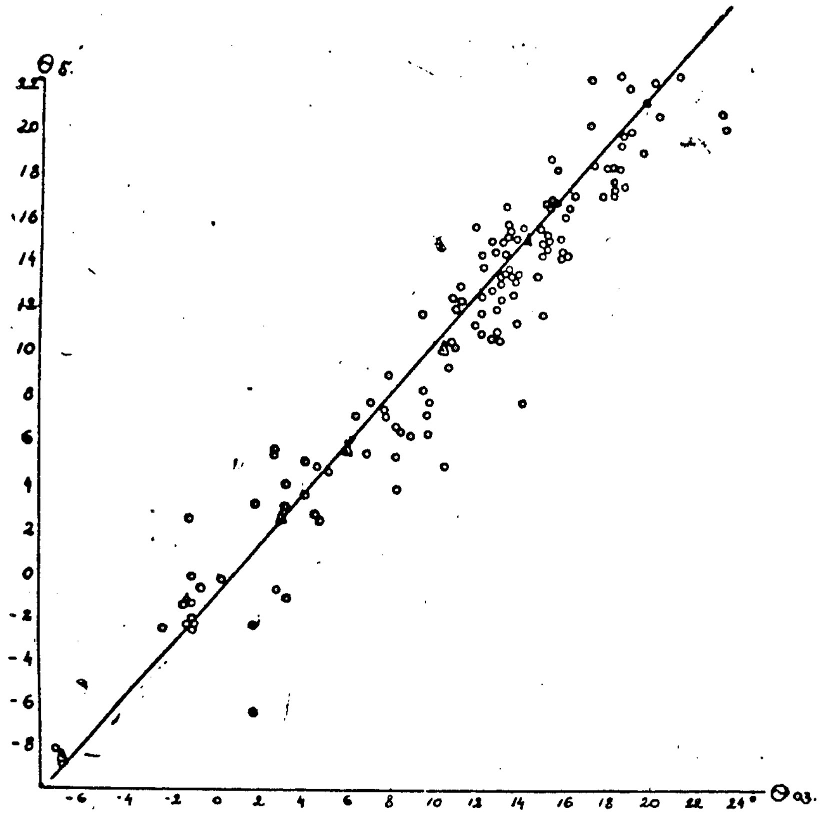

Fig. 2. - the graph of connection of simultaneously measured temperatures of air in the deep-water parts of lake (Θ_{03}) and at coastal posts (Θ_6).

Page 49.

Numerical values F_Θ separate for Small and Large Sevan in each month were obtained by the comparison of the synchronous values of temperatures above the land and lake.

The observations, which were used for the determination of value F_Θ related to the day time. However, observations at the floating station showed that connection of daytime and daily average

temperatures of air above the lake and on the shore are different. In the day time this connection, shown in Fig. 2, takes the form:

$$\Theta_{B} = 0{,}90\Theta + 1{,}0 \qquad (3)$$

For daily average temperatures at floating station and coast communication post (see Fig. 3) is obtained in the form:

$$\Theta_{B} = 0{,}78\Theta + 4{,}3 \qquad (4)$$

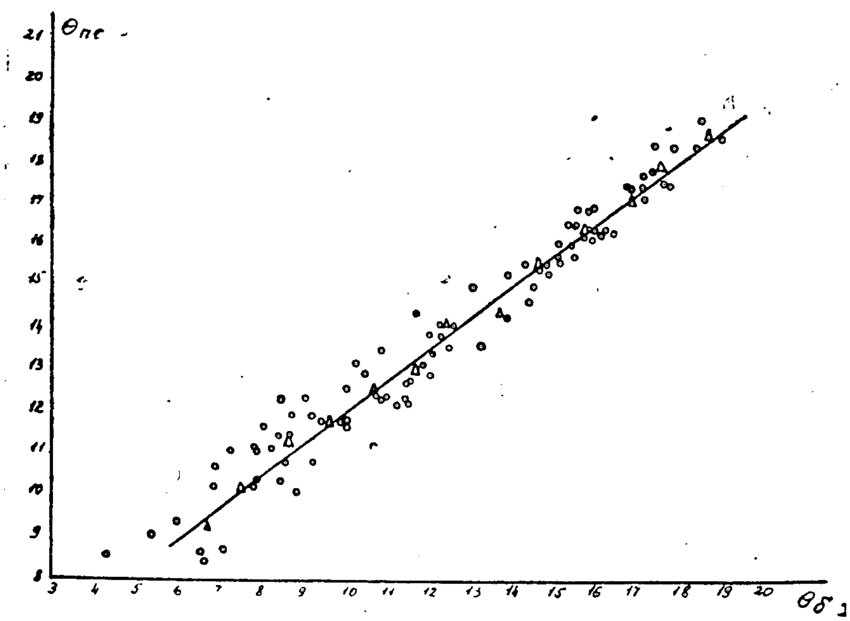

Fig. 3. - the graph of connection of average daily temperatures of air at floating station (Θ_{nc}) and coast post (Θ_6).

Page 50.

The analysis of connections of the temperature at the floating station and on the shore in the day time (13 h.) and night (01 h.) showed that the warming up effect of lake in the summer and autumnal months is especially strongly manifested by night. For this reason one ought not to utilize for calculating average temperatures of air in the open basin of the ratios, obtained on the basis of observations in the day time.

After working entire material of observations on the shoreline and in the open lake (710 cases, from which 360 daily average values) for the purpose of obtaining values F_{Θ} for each month, were found

monthly average values F_Θ, new single for entire lake which were shown in Table 1.

Now the temperature of air above the lake was calculated from formula (2) with new values F_Θ. As the temperature above the land were utilized the given at the stations Sevan-island, Shorzha, Martuni, Noraduz, Sevan, Kama, which introduced to the shoreline with the aid of the very reliable dependences, the obtained by the comparison of average monthly temperatures at the station and on the shore:

For reduction are used the ratios:

for Shorzha $\Theta=0,97\Theta c+0,3$, station

for the Martuni stations and Sevan GMS $\Theta=0.90\Theta c+0,9$,

for Kama station $\Theta=0,95\Theta c+1,7$ (5)

Data of stations Sevan-island and Noraduz can be with a sufficient degree of accuracy considered related to the shoreline.

Table 1.

(a) M-ц	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
F_{Θ}	0,10	0,20	0,15	0,35	0,35	0,35	0,15	0,15	0,25	0,40	0,30	0,10

Key: (a). Matrices.

Page 51.

For calculating the temperature above small Sevan should be utilized data of the stations: Sevan-island, Sevan and Shorzha, after averaging them after reduction to the conditions of coast, and then after producing calculations according to formula (2) with the coefficients from Table 1. Above large Sevan the temperature is calculated thus, utilizing data of the stations: Shorzha, Martuni, Kama (or Noraduz). The temperature of air above the entire water area can be defined as medium-weighted of temperatures above Small and Large Sevan taking into account their areas.

The comparison of calculated thus temperatures with the observational data in the open lake gave somewhat better results, than the method of GGO (average disagreement with the observations in 10 months using this method equal to 0.2°, using the method of GGO - 0.5°).

b) the humidity of air above the lake using the method of GGO [12] is determined according to the observational data on the shore with the aid of the ratio:

$$e_{в} = e_{c} + (e_{0} - e_{c}) \cdot e_{e} \qquad (6)$$

Here e_c - humidity of air above land,

e_0 - maximum vapor pressure with this temperature, surface of basin;

F_c - function, whose values were determined by the comparison of the simultaneous values of humidity above the land and above the basin separately for Small and Large Sevan.

The calculations of humidity above the basin according to formula (6) must be brought, generally speaking, to the overstated values in view of the structure of formula, since assumption about that which $e_{np}=e_0$. assumed as the basis of formula, is not sufficiently in this substantiated. The studies, carried out by Braslavskim and Vikulinoy [3], showed that $e_{np}<e_0$ comprises approximately $0,8e_0$ even with the unlimitedly prolonged stay of air above the basin.

The observations at coast posts organized in recent years made it possible somewhat otherwise approach a question about the determination of moisture content above the basin according to the observational data at coast posts.

Page 52.

Utilizing data OF ultaneous (disagreement in the time does not exceed 0.5 hours) observations of absolute humidity at coast posts and in the lake near these posts, and also daily average of given on to raft and floating station, it was established that the humidity of air above the lake on the average on 0.5 mb. is more than humidity on the shore (see Fig. 4).

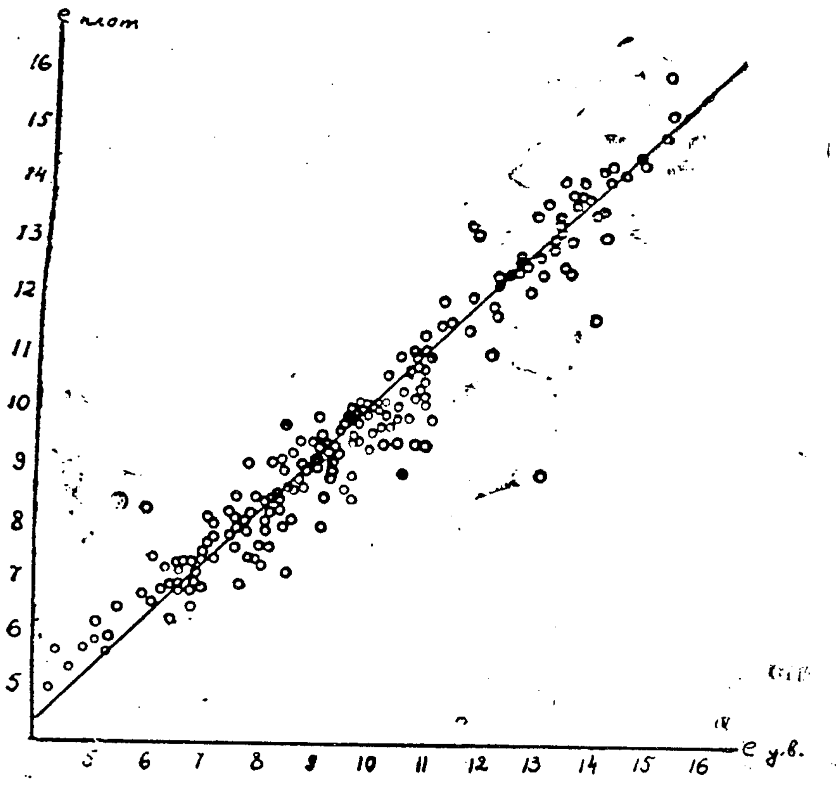

Fig. 4. - the graph of connection of absolute humidity (mb.) on the shoreline ($e_{yб}$) and on to raft (e_n).

Page 53.

Consequently, during the calculation of the average monthly values of humidity it is possible with a sufficient degree of accuracy to utilize for the transition from the humidity on the shore to the humidity on the water area of lake a correction equal to 0.5 mb. The data of stations are cited in the conditions of coast with the aid of the very simple and reliable dependences, obtained by the comparison of average monthly values on area and coast post (during the 4th observations at standard time) for the stations:

Kama, Shorzha, Sevan $e_б = 1,10e_c - 0,3$

Martuni $e_6 = e_c + 0.5$ (7)

Here $e_б$ - humidity on the shore, e_c - humidity on the meterological platform. Humidity on the area of station Sevan-island can be considered equal to the humidity on the shore.

Thus, humidity above the lake was calculated according to the data of the same stations as temperature, by reducing humidity at the station to the conditions of coast and by addition to the given constant value correction of the equal to 0.5 mb.

The comparison of that calculated by this method of the average monthly values of humidity with the calculations according to the method of GGO and according to the method IVP [10], and also with the observational data at the floating station in 10 months (see Table 2) showed that it gives the same results as method IVP and differs little from the observations. Using the method of GGO the overstated values of humidity are obtained (on the average to 6%).

Table 2. Average monthly absolute humidity (in mb.) above Lake. Sevan, calculated by different methods.

(a) Год	1960 г.						1961 г.			
(b) м-ц	VIII	XI	X	XI	XII	I	IV	V	VI	VII
(1) Наблюдения	13,2	11,3	8,4	6,3	4,7	3,9	6,3	8,6	11,7	13,7
(2) Способ ГГО	15,1	12,6	9,0	6,5	4,9	3,7	6,3	8,4	12,3	15,2
(3) Способ ИВП	13,5	11,2	7,4	6,0	5,0	3,7	6,5	8,4	11,2	13,6
(4) Способ автора	12,9	10,4	7,8	6,0	4,5	3,9	6,6	8,5	11,7	14,3

Key: (a). Year. (b). matrices. (1). Observations. (2). Method of GGO. (3). Method IVP. (4). Method of author.

Page 54.

c) wind speed above the water surface is calculated usually with the considerable errors, which are caused by a number of the reasons: the absence of stationary observations of the water surface, the large variability of the wind and the difference in the nature of its change upon transfer of air mass from one underlying surface to another.

In recent years at Lake Sevan was carried out the very careful study of wind [12], which made it possible to develop in GGO the method of calculating wind speed above the lake according to the observational data coast meteorological stations.

Utilizing observational data on the weathercock at the stations Sevan-island, Sl...zha, Martuni, after introducing them to the conditions of water surface and the height of 2.0 m with the aid of the empirical ratio

$$U_2 = 1{,}2\,(1 + 0{,}55\;U_{\phi}), \qquad (7)$$

it is possible to determine wind speed above Small and Large Sevan. In small Sevan are averaged given according to formula (7) data of stations the Sevan-island and Shorzha; Large - corresponding data of the stations of Shorzha and Martuni. Wind speed above the entire water area is located as the weighted average of the values of the speeds in Small and Large Sevan.

There is another method of determining wind speed above the water surface according to the data of stations Sevan-island, Shorzha, Kama, Martuni, Mazra with the aid of the separate empirical formulas, which connect data of weathercock with the shoreline (method IVP) [10].

The observations of the last years at coast posts and at the floating station showed that both these of method insufficiently consider an increase in wind speed upon its transfer from the land to water surface.

Daily average wind speeds at coast post Sevan-island and raft, located 300-400 m south of the coastal post, were compared. These observations are reliable and fully comparable, since in both cases of measurement they were carried out within 4 climatological periods, at one height (2 m) by the identical instruments (anemometers).

Page 55.

The results of comparison are shown to Fig. 5, wind speed on raft on

the average to 25% higher than on the shore. However, a similar comparison was conducted according to the data coast post Noraduz and floating station in the time, when floating station was located in Large Sevan at 4.5-5 km from Noraduza. Giving the speeds, measured at the floating station at the height of 3 m, to the height 2 m according to the logarithmic rule, utilizing $z_0 = 10^{-4}$ M, they obtained that at the floating station the speed is 30-35% higher than on the shore. All this gives grounds to assert that wind speed above the water surface on the average is up to 30% greater than in shoreline.

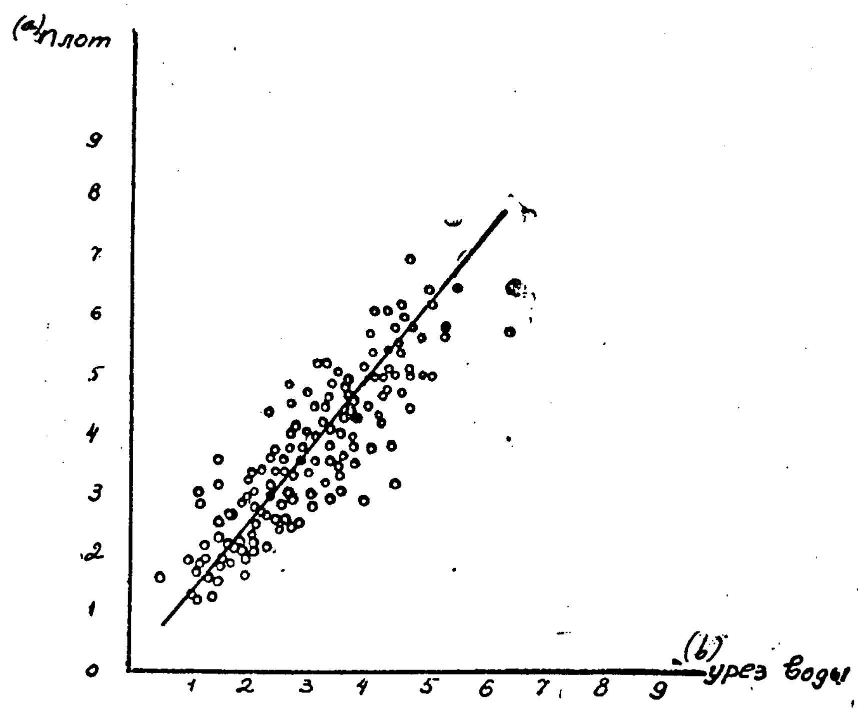

Fig. 5. - the graph of connection of average daily wind speeds on to raft and coast post in Sevan peninsula.

Key: (a). raft. (b). shoreline.

Page 56.

If we increase the speed, measured at coast posts, to 30% and to compare it with the observational data at the floating station and with the calculations according to the method IVP (see Table 3), it is possible to establish that the speeds, calculated according to the method IVP on the average are up to 18% lower than that according to the observational data, whereas the given data of posts coincide sufficiently well with the those observed (on the average up to 6% lower than that observed). Hence it is possible to indirectly evaluate errors in the method of GGO. Comparison of average monthly

wind speeds above small and Large Sevan, calculated according to the method GGO and according to given data of posts, showed that calculations according to the method of GGO only up to 3% on the average is lower than before. Therefore it is possible to consider that calculation according to the method of GGO will give in comparison with the observations somewhat understated data (to 6-10%).

In connection with this, although during the determination of wind speed for 1951-60 yrs. (see Table 3 of appendix) the method of GGO without the changes was used, one should consider during the composition of balance that these speeds, will prove to be understated.

After calculating the values of temperature, the humidities of air and wind speed in each month of 1951-60 yrs. (see Table 1, 2, 3 Appendices), can be passed to the examination of the elements of heat balance during this period.

Table 3. Wind speeds above the water surface, calculated by different methods.

(a) Метод определения	1960 г.					1961 г.				
	VIII	IX	X	XI	XII	I	IV	V	VI	VII
(1) Наблюдения на пл. станции	4,1	3,8	3,6	4,2	4,6	5,1	3,6	3,3	3,3	3,9
(2) Расчет по способу ИВП	3,1	3,1	3,1	3,1	3,5	4,0	3,2	3,0	3,0	3,3
(3) Приведенные данные постов	4,2	3,9	3,9	3,9	4,2	4,5	3,1	3,2	—	—

Key: (a). Method of determination. (1). Observations at floating station. (2). Calculation according to method IVP. (3). Given data of posts.

Page 57.

3. Radiation balance.

In connection with the absence of systematic measurements on the water surface its radiation balance (R) is determined, as a rule, by calculation. At Lake Sevan, where in 1959-60 the radiation balance of water surface in the coastal zone systematically was measured, and in 1960 observations on the open lake at the floating station was conducted, the possibility to evaluate the existing methods of calculation appeared.

If the actinometric observations at coast meteorological stations are conducted, the radiation balance of water surface can be calculated from the measured radiation balance of land by method, presented into [8]. Calculation formula in this case takes the form:

$$R = R_c + Q(A_c - A) + 4\delta\sigma\Theta^3(\Theta_c - \Theta_w) \qquad (8)$$

here:

R_c, A_c, Θ_c - respectively radiation balance, albedo and temperature of the surface of land,

R, A, Θ_w - the same, characteristic for the conditions of lake,

Q - total radiation,

δ - radiation coefficient of the underlying surface,

σ - Stefan-Boltzmann constant,

Θ - temperature of air.

In the absence of the actinometric observations R is determined according to the weather data with the aid of the known formula:

$$R = Q_0[1-(1-k).\, u](1-A) - E_0(1-cn^2) - 4\delta\sigma\Theta^3(\Theta_w - \Theta), \qquad (9)$$

where: Q_0 - total radiation in the cloudless sky (possible radiation),

E_0 - effective emission in cloudless sky,

n - cloud amount of middle level, expressed in the portions of one,

k, c - empirical coefficients (under the conditions of Lake Sevan was accepted k=0.60, c=0.68).

Page 58.

The sufficiently reliable values of the albedo of water surface at Lake Sevan in each month are given in [12]. Calculations according to the formulas indicated were fulfilled separately for Small and Large Sevan, moreover during the use of formula (8) the radiation balance of Small Sevan was calculated according to the data of station Sevan-island (Θ_w - average for Small Sevan), Large Sevan - according to the data of Martuni station (Θ_w - average for Large Sevan).

The comparison of the monthly sums of the radiation balance of water surface in 1959, obtained by calculation according to formula (8) and according to the observational data (see Table 4) was carried out.

Insignificant differences in observed and calculation data (difference in the monthly sums in 10 cases of 12 do not exceed 0.8 kcal/cm^2, differences in the annual sum of less than 3%) confirms given earlier into [12] conclusion that the radiation balance of Small Sevan with a sufficient accuracy can be calculated according to formula (8).

The comparison of the observed and calculated by formula (8) monthly sums of radiation balance in Large Sevan in the time, when measurements at the floating station were made, showed that R_p always exceeds R_H (see Table 5).

Table 4. Monthly and the annual sum (kcal/cm²) of the radiation balance of water surface on the coast in Small Sevan according to calculation (R_p) and according to observations ($R_н$)

(a) М-ц	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	(b) год
$R_н$	0,7	1,2	1,6	8,5	10,2	12,1	13,8	11,0	7,8	4,2	1,7	1,2	73,5
R_p	0,7	1,2	2,0	7,9	10,8	12,9	13,6	10,4	8,0	2,8	1,2	0,0	71,5

Key: (a). Matrices. (b). year.

Page 59.

The constant sign of difference $(R_н - R_p)$ makes it necessary more attentively to estimate calculation data.

By comparing the calculations, carried out according to formula (8) for Small and Large Sevan, it is possible to reveal that the radiation balance of water surface, calculated according to the data of Martuni station, considerably exceeds the balance, calculated according to the data of station the Sevan-island (see Table 6).

Characteristically, the differences in the monthly sums decrease also August to November, as this was shown in the previous table. It is not possible to explain such considerable disagreements in the radiation balance of the individual parts of the lake (annual sum in Large Sevan to 20% greater than in Small) by physical causes.

Table 5. Monthly sums of the radiation balance of large Sevan in 1960 according to the observational data ($R_н$) and calculation ($R_р$) (kcal/cm²).

(a)М-ц	VIII	IX	X	XI
Rн	12,2	8,3	3,7	0,6
Rр	13,7	8,8	3,9	0,8

Key: (a). Matrices.

Table 6. Monthly sums of radiation balance (average for 1958-60 yrs.), calculated for Small and large Sevan (kcal/cm^2).

(a)М-ц	I	II	.II	IV	V	VI	VII	VIII	IX	X	XI	XII	(b)год
R М.С.	0,8	3,0	4,7	8,9	12,2	12,6	12,8	11,4	6,9	2,9	0,4	0,9	75,7
R Б. С.	1,7	3,8	5,7	10,3	13,7	14,7	15,9	13,1	7,8	3,2	0,6	0,2	90,7

Key: (a). Matrices. (b). year.

Page 60.

Actually, the differences in total radiation of these parts of the lake comprise is on an average 6%; the albedo of the entire surface of lake is equal; the estimation of differences in the effective emission showed that in the year they cannot be more than 3-4% under the most unfavorable conditions. The radiation balance is natural. Large Sevan must not exceed the radiation balance of Small Sevan more than 10%.

Above has already been discussed the fact that for Small Sevan it is calculated according to formula (8) with a sufficient accuracy. Consequently, unnaturally large disagreements in the annual and monthly sums are the consequence of the fact that for Large Sevan the calculation according to the data of Martuni station does not provide a sufficient accuracy. This is explained by the insignificant, at first glance, circumstance, connected with the structure of formula.

If at the station Sevan-island the nature of the section, where actinometric observations are conducted and the temperature of soil is measured, is completely identical (bare stony soil), then at Martuni

station actinometric observations are conducted of the plant cover (green, and then dried grass), and the temperature of soil is measured in the bare chernozem section. The temperature of soil in the bare section is higher than the temperature of plant cover, and albedo are less.

Due to this, the radiation balance of basin, calculated according to the data of Martuni station with the aid of formula (8), will be overstated due to the nonconformity of the temperature of soil and measured components of the radiation balance of land (first of all of albedo). By the same it is possible to explain the noted above decrease of differences in calculation and observed data from the summer to the autumn (August-November). In autumn grass dries, differences in albedo and temperatures of the covered with grass and bare section decrease and area becomes more uniform.

Consequently, to calculate the radiation balance of Large Sevan according to the data of Martuni station, as recommended in work [12], does not follow, since in this case they are obtained, especially into the summer time, the overstated values of balance.

Page 61.

Calculations can be performed, strictly speaking, only in the presence of snow cover, when area is uniform. Therefore during the determination of the radiation balance of Large Sevan it was necessary to forego the application of formula (8).

It is advisable to introduce the supplementary condition during the calculation of the radiation balance of basins according to the known balance of land requirement about the uniformity of the underlying surface of actinometric area and section for determining the soil surface temperature.

The comparison of calculations according to the weather data with the aid of formula (9) with the observational data of the water surface showed that their differences are comparatively small (average difference in the monthly sums is 0.6 kcal/cm²); moreover calculated values, as a rule, are less than measured. Calculations according to formula (9) were compared also with the calculations according to formula (8); disagreements in the annual sum were about 3%. Therefore it seems that the calculations according to formula (9) provide approximately the same accuracy as according to formula (8), i.e., sufficiently reliable monthly sums.

Radiation balance for 1951-60 g. was determined for Large Sevan by calculation according to the weather data with the aid of formula (9); for Small Sevan since 1951 to June 1956 - by calculation according to the weather data, from July 1956 through 1960 - on the radiation balance of land with the aid of formula (8).

In connection with the fact that the area of Large Sevan more than two and one-half times exceeds the area of Small Sevan, and

differences in their radiation balance in the separate months are essential, the radiation balance of entire lake was defined as its weighted average value in Small and Large Sevan in accordance with the areas of these parts of the lake.

Thus, in all months of 1951-60 g. g. determined the radiation balance of the lake (see Table 4 of appendix), whose short characteristic is given below.

Average many-year radiation balance of water surface in all months, except December, is positive.

Page 62.

Negative balance occurs only during December. In the year the lake is obtained on the average of 77.5 kcal/cm². In this case the greatest admission is observed during June - July, when water surface obtains in the month of 13 kcal/cm².

The radiation balance of Small Sevan on the average in the year is 3.1 kcal/cm² less than Large (to 4%).

In those years, when stable ice cover is formed on the lake, radiation balance in the year as a whole decreases by 10-20% in comparison with the non iced year. Thus, if average in the non iced 7 years the radiation balance is equal to 80.8 kcal/cm² year, then in 1954 it was equal to only 70.6 kcal/cm² (87%), in 1957-66.5 kcal/cm²

(82%), in 1959, when lake froze for one month - 73.3 (91%).

A considerable increase in the portion of reflected radiation with the formation of ice cover, especially under the conditions of snow cover leads to the fact that the radiation balance of surface of lake which is covered with ice and snow, becomes even less than the radiation balance of land.

Further decrease of a volume of water mass and transformation of lake into the yearly freezing basin will lead thus to the noticeable decrease of its radiation balance (approximately to 15-20% in comparison with the contemporary).

4. The turbulent heat exchange of lake with the atmosphere.

For the course of almost a full year the temperature of the surface of water of lake differs more or less considerably from the temperature of the current air layer. These differences determine the existence of heat flow, caused by the process of turbulence in surface boundary layer. This heat flow under specific conditions can be very considerable, and therefore one should determine sufficiently reliably during the composition of its heat balance.

Page 63.

The direct measurements of turbulent heat exchange (P) on the hydrometeorological network is not conducted, therefore this component

of heat balance is determined by calculation. There is a considerable number of empirical and semi-empirical methods (formulas), used for determining P of water surface. In the work is carried out the investigation of many of them for the conditions of Lake Sevan.

So, in particular were conducted calculations according to V. V. Shuleikin's formula:
during the positive heat exchange

$$P=0{,}021(\Theta_w-\Theta_B)\ \frac{^{(1)}\text{кал}}{\text{см}^2\text{мин.}} \qquad (10)$$

Key: (1). cal/cm² min.

during the negative heat exchange

$$P=3\times10^{-4}(\Theta_B-\Theta_W)\frac{^{(1)}\text{кал}}{\text{см}\cdot\text{мин,}}$$

Key: (1). cal/cm min.

which in its time was utilized at Lake Sevan by V. K. Davydov, although its many deficiencies now are completely obvious.

The formulas of the form were investigated:

$$P=C_p\cdot\rho\cdot a\cdot u(\Theta_W-\Theta_B) \qquad (11)$$

where a - empirical coefficient, which characterizes the hydrodynamic properties of water surface and air with respect to heat exchange,

ρ - air density,

C_p - heat capacity at constant pressure.

Coefficient a in formula (10) can be determined by different methods, in particular, according to the equation of heat balance, if its remaining components are known.

During the composition of the "atlas of heat balance" for the conditions of world ocean, M. I. Budyko [5] considered it possible to accept value $\rho=2{,}4\times10^{-6}$ g/cm³ and not depending on wind speed. In this case formula (11) takes the form:

$$P=0{,}0035\,(\Theta_w-\Theta_в)\cdot U\ \frac{^{(1)}\text{кал}}{\text{см}^2\,\text{мин}} \qquad (12)$$

Key: (1). cal/cm² min.

Page 64.

In the last investigations of GGO, carried out at Lake Sevan under M. P. Timofeev's management, for calculating the turbulent heat exchange was used the formula, in which during the determination of coefficient of a was considered temperature stratification [12]. It can be written

$$P=0{,}163a_1\cdot U_1\cdot(\Theta_w-\Theta_z) \qquad (13)$$

$$^{(1)}\text{причем}\ \ a_1=a_{1,0}\cdot\left(1-1{,}25\frac{\Delta\Theta}{U_1^2}\right)$$

Key: (1). moreover.

Here a value a¹ under the equilibrium conditions will increase with an increase in wind speed and depends on the parameter of roughness. The effect of temperature stratification is considered by the second term of bracket.

V. S. Samoylenko [11], utilized the idea of Sverdrup, which applied to the investigation of the turbulent heat exchange of basins and atmosphere theory of turbulence and obtained the comparatively simple formula:

$$P=C_p\cdot\rho f^2\frac{(\Theta_W-\Theta_z)\cdot U}{ln^2\left(\frac{z+z_0}{z_0}\right)}, \qquad (14)$$

where f - constant of Karman =0.38, and z_0 - parameter of roughness.

When there is data about the radiation balance (R), and a change of the enthalpy in the water (B) obtained from the observations of temperature, it is possible to utilize a known "attitude of Bowen" for determining the turbulent heat exchange in the form:

$$P=\frac{R-B}{1+1,9\frac{e_e-e}{\Theta_W-\Theta_B}} \qquad (15)$$

Coefficient in formula (15) is obtained for the conditions of Sevan lake.

All formulas indicated were used for calculating the monthly and annual values of heat exchange on Lake Sevan in order to select most acceptable of them.

Page 65.

In this case in formula (14) z_0 accepted equal to 10^{-4} m, the

calculations according to formula (13) were performed in accordance with the procedure, presented into [12]. As the initial data were used the averaged in 10 years (1951-60 yr) values of temperature and wind speed in each month separately for Small and Large Sevan.

The results of calculation are shown in Table 7.

The carried out calculations of turbulent heat exchange made it possible to draw some conclusions.

1. The values of positive heat exchange, calculated by formula (10) (Shuleikin's formula), considerably exceed the heat exchange, calculated according to other formulas. During the negative heat exchange V. V. Shuleikin's formula, on the contrary, gives, considerably understated, in comparison with other formulas, values. If we examine the heat exchange, calculated according to this formula as the element of heat balance, then its inadequacy becomes obvious. Actually, the annual radiation balance of Small Sevan is equal to 75.3 $kcal/cm^2$. If we accept the annual value of heat exchange, calculated according to formula (10) (37.9 $kcal/cm^2$), heat consumption per evaporation and turbulent heat exchange will prove to be approximately equal, and the value of evaporation will comprise in that case only of 630-640 mm per annum.

2. The smallest values of heat exchange are obtained according to the formula of V. S. Samoylenko (formula 14). This is connected

first of all with the errors during the determination of the parameter of roughness, since the structure of this formula so that even comparatively small changes z_0 give noticeable changes in the input of the formula coefficient. Actually, if we accept z_0 as equal not 10^{-4} m, and as 10^{-3} m, then the coefficient of formula will become equal to 0.0035, i.e., formula Samoylenko will not differ from formula (12).

From [12] it is known that z_0 is changed in the lake Sevan in the sufficiently wide limits (from 10^{-6} m to 10^{-3} m), increasing with the increase of wind speed.

Page 66.

Table 7. Monthly sums of turbulent heat exchange in Small and Large Sevan (kcal/cm²).

	(a) Формула / (b) Месяц	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	(c) Год
(1) М. Севан	(a) Формула 12	4,64	3,36	2,12	—0,43	—0,89	0,26	1,06	1,33	2,05	2,24	3,30	4,90	23,94
	(a) Формула 14	2,78	2,01	1,27	—0,26	—0,53	0,15	0,64	0,79	1,23	1,34	1,98	2,87	14,37
	(a) Формула 13	4,87	2,99	1,65	—0,20	—0,39	0,15	0,76	1,04	1,83	1,91	3,47	5,75	23,83
	(a) Формула 15	4,23	2,96	2,28	—1,40	—0,99	0,09	0,20	0,85	1,74	1,97	3,46	4,51	19,90
	(a) Формула 10	6,37	4,83	3,37	—0,04	—0,05	0,45	1,69	2,06	3,36	3,66	4,98	7,22	37,90
(2) Б. Севан	(a) Формула 12	3,98	2,74	1,56	—0,56	—0,03	0,08	0,13	0,46	1,68	1,89	3,20	4,53	19,66
	(a) Формула 14	2,48	1,64	0,94	—0,33	—0,26	0,05	0,08	0,27	1,01	1,13	1,92	2,72	11,65
	(a) Формула 13	4,05	2,51	1,17	—0,26	—0,19	0,05	0,09	0,35	1,38	1,75	3,19	4,96	19,05
	(a) Формула 15	3,23	2,41	1,80	—2,16	—0,05	1,10	0,15	0,52	1,61	1,91	3,04	4,78	17,34
	(a) Формула 10	5,72	4,15	2,62	—0,05	—0,01	0,18	1,22	1,88	3,27	3,47	5,08	7,04	34,57

Key: (a). Formula. (b). Month. (c). Year. (1). S. Sevan. (2). L. Sevan.

Page 67.

Under these conditions errors in such order, which now was examined in an example, are completely possible.

Consequently, the application of the formulas, into which directly enters z_0, to the degree higher than first (formula Samoylenko and Kuz'mina), connected with the considerable errors and cannot be recommended for the lake Sevan.

3. The values of heat exchange, calculated according to formulas (12) and (13) are very insignificantly distinguished. Thus, the

disagreement in the annual sums for Small Sevan composes 0.5%, for Large Sevan - 3%. In the monthly sums the greatest differences occur during December, when in Small Sevan reach 0.85 kcal cm^2. The differences are considerably less in other months.

4. The turbulent heat exchange, calculated according to formula (15) is somewhat less than according to formula (12) and (14) (on the average up to 15% during the comparison of annual sums). During the negative heat exchange, when the difference between the radiation balance and the heat exchange in the water is smallest, and differences in temperatures and vapor pressures are compared in the value and are opposite according to the sign, calculations according to formula (15) lead to the most considerable errors, which is connected with the structure of formula itself.

Noticeable systematic errors during calculations by this method must occur in the summer months in the presence of advection. In this case in Small Sevan the heat exchange must be somewhat understated, and in the Large - overstated.

Thus, the use of the "ratio of Bowen" during the negative heat exchange and in the presence of advection does not follow.

Page 68.

The comparison of the values of heat exchange, calculated by different methods, showed that during the composition of heat balance

under the conditions of lake Sevan the simplest and at the same time precise method of determining the heat exchange is the calculation according to formula (12). As the initial data in this case should be utilized the values of the temperature of air and wind speed above the lake at height of 2.0 m. This method can be recommended for calculating the turbulent heat exchange during the composition of the subsequent heat balance.

With the same accuracy is calculated turbulent heat exchange from formula (13); however, calculation itself in this case is more complex.

Data of calculation makes it possible to give the short characteristic of turbulent heat exchange at Lake Sevan. Turbulent heat exchange in Small Sevan occurs more intensely, than in the Large Sevan, which is determined by differences in wind speed and in the temperature of air above these parts of lake. Differences in the temperature have greatest value in winter period, differences in speed of wind - in summer.

In Small Sevan the annual heat consumption per turbulent heat exchange composes approximately 30% of annual radiation balance, Large - somewhat less than 25%.

The annual variation of turbulent heat exchange has well expressed maximum during December. The value of turbulent heat

exchange during January is somewhat less. In the individual years, mainly with the ice formation, the maximum of turbulent heat exchange can be displaced in January and even February (1959).

It should be noted that during December-February the heat consumption per turbulent heat exchange is equal or somewhat exceeds heat consumption per evaporation. In the remaining time on the turbulent heat exchange is expended considerably less heat than for the evaporation. The smallest values of turbulent heat exchange in the absolute value occur in May-June, which is caused by insignificant differences in the temperature of water and air in these months. During April and May, when air is warmer than the water, heat exchange is negative, and very insignificant in the value.

Page 69.

5. Surface evaporation Lake Sevan.

Under the conditions of Lake Sevan is evaporation - one of most considerable components of water balance, which causes the annual loss of water by lake, which approach in the value annual faults through the water-engineering constructions of the head power station of Sevan-Razdanskogo stage. Therefore in the works of the last years extremely great interest became apparent in the refinement of the value of evaporation. This question, incidentally, did not lose its urgency up to now both in the practical and in the scientific sense. The information about surface evaporation Lake Sevan is given in works

[6, 7, 10, 12]. During calculations of evaporation there were utilized various methods: the method of evaporators (hydrometeorological method), turbulent diffusion, water balance. Some estimations according to the method of heat balance were also conducted. And nevertheless it cannot be considered that the value of evaporation is determined completely reliably. It suffices to note that difference within the norm of evaporation in the different authors reaches 10-12%, which under the conditions of Lake Sevan is not possible to consider satisfactory.

For this very reason one of the basic problems of this work is the determination of the value of evaporation the method, which has the substantiated criterion for evaluating the accuracy of the obtained values.

The results of applying the heat balance for determining the value of evaporation will be examined below. It is here expedient to dwell on some questions, connected with the independent determination of evaporation with other methods and with its special features under the conditions of Lake Sevan.

a) on the basis of the materials of evaporation basin in Sevan GMO the author obtained the formula for calculating the evaporation (hydrometeorological method), which since 1958 was used during the composition of the annual and monthly water balances of lake.

Page 70.

Sevan evaporation basin acts since 1950 to the present time. It is established on the island (now peninsula) in its western part in small increase, which at that time was the western cape of island. The materials of observations during 1950-58 were used for the derivation of formula.

In this case the daily sums of evaporation and the daily average values of absolute humidity, maximum vapor pressure and wind speed were grouped in terms of the values of the speeds in the range of 1.0 m (from 0 to 1.0 m/s; from 1.1 to 2.0 m/s, etc.). After critical analysis and elimination of the doubtful cases for each interval of speed the average sum of evaporation and the average values of all elements, was determined. In the obtained averaged values was obtained the graph which connects relation $\left(\frac{10E}{e_0 - e}\right)$ with wind speed (U_2). Graph is represented in Fig. 6, the analytical expression of connection takes the form:

$$\frac{10E}{e_0 - e} = 0{,}85U_2 + 2{,}6 \qquad (16)$$

The total number of cases examined during the conclusion of dependence (16) is equal to 1565, of them it was rejected 14 (0.2%). The coefficient of correlation of obtained connection is equal to 0.99.

By reducing expression (16) to usual form, we will obtain formula

for calculating surface evaporation of lake during the period of p days:

$$E=0,26(e_0-e)(1+0,33U_2)n \qquad (17)$$

It should be noted that further increase in the series of observations does not affect the values of the coefficients, determined according to the data in 9 years, which proves stabile and reliable of the obtained dependence.

Page 71.

However, the position of Sevan evaporation basin is such, which makes it possible to doubt the applicability of the produced formula for the calculations of surface evaporation of lake without the supplementary corrections.

As already mentioned, Sevan evaporation basin (main area) was located on a comparatively small increase, which, however, in proportion to lowering the level of lake, becomes more noticeable. Thus, toward the end of 1960 the excess of evaporation basin above the level of lake comprised less than 15 m, whereas during the installation of basin (1950) it was equal to approximately 6 m.

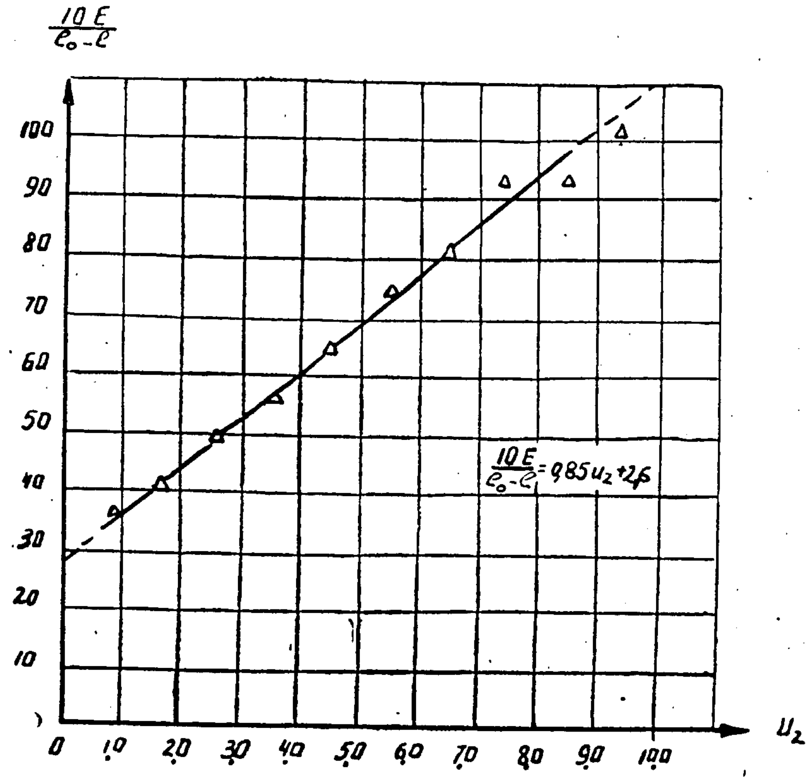

Fig. 6. - the graph of connection of the value of evaporation, referred to one difference in the vapor pressures and wind speed of upper 2 m.

Page 72.

If one takes into account, that the distance from the coast of lake to the site of installation of basin even in 1960 did not exceed 110-120 m from the northern side (from the south somewhat more), then it is natural to assume that this elevation can have an effect on air flow above it and consequently to surface evaporation of evaporation basin.

For the purpose of checking this assumption was organized the

supplementary evaporative area, equipped with evaporator GGI-3000. Place for the area was selected in such a way as to eliminate the effect of elevation on wind current. It was located approximately 100 m west if the main area, hereabout from the southern shore of peninsula at the open plane place.

The comparison of the monthly sums of evaporation on the same-type evaporators on two areas showed that in the summer time, when are observed, in essence, the northern winds, evaporation on main area is up to 14-18% more than on the supplementary (see Table 8).

During September and October, when the direction of the prevailing wind currents are southwestern, differences in the values of evaporation on these two areas noticeably decrease.

It is interesting to note that in the summer months the most considerable excess in the values of evaporation is observed in night hours, in the daytime differences are less.

By examining the factors, which determine the value of evaporation, it is easy to note that also wind speed and difference in the vapor pressures (e_0-e) on main area are more, than on the shore (see Table 9).

Table 9. Ratio of the wind speed (U) and the difference in the vapor pressures (e_0-e) on main and supplementary areas in 1960.

(a) Месяцы	V	VI	VII	VIII	IX	X
Uo/Uд	1,11	1,17	1,12	1,35	1,30	1,22
$(e_0-e)_0/(e_0-e)_д$	1,02	1,13	1,22	1,11	1,14	1,14

Key: (a). Months.

Page 73.

Table 8. Monthly sums of evaporation in 1960 on main and supplementary areas on evaporator GGI-3000 (mm).

(a) Месяц / (b) площадка	(c) Август			(d) Сентябрь			(e) Ноябрь		
	19—7	7—19	Σ	19—7	7—19	Σ	19—7	7—19	Σ
(1) основная (E_0)	53	91	144	73	86	159	77	93	170
(2) дополнит. ($E_д$)	46	78	124	85	82	140	63	81	144
($E_0/E_д$)	1,15	1,16	1,16	1,26	1,05	1,14	1,22	1,15	1,18

Месяц (a) / площадка (b)	(f) Май			(g) Июнь			(h) Июль		
	19—7	7—19	Σ	19—7	7—19	Σ	19—7	7—19	Σ
основная (E_0) (1)	94	107	201	58	85	143	42	67	109
дополнит. ($E_д$) (2)	78	99	177	56	79	135	41	62	103
($E_0/E_д$)	1,21	2,08	1,14	1,04	1,08	1,06	1,02	1,08	1,06

Key: (a). Month. (b). area. (c). August. (d). September. (e). November. (1). main. (2). supplement. (f). May. (g). June. (h). July.

Page 74.

Their comparison in the summer months (V-VIII) separately for the daytime (13 hours) and night period (01 hour) showed that the more considerable differences in the evaporation in the night time are explained by the fact that at night a difference in the elasticities on main area is noticeably more than on the shore, whereas in the daytime they do not differ (see Table 10). Differences in wind speed are most significant in second half of day approximately in the

evening period of observations (to 40%), in the remaining time of day wind speed on area at the height of 2.0 meters to 15-20% exceeds the same on the shore.

The basic reason for a higher difference in the vapor pressures on main area as showed analysis, is the higher temperature of water in this evaporator.

Besides an increase in wind speed and stronger heating of water in the evaporators on main area the definite effect on the evaporation must exert a certain distortion of the vertical structure of air flow above this elevation.

For all these reasons, at present, the Sevan evaporation basin cannot be considered representative, in consequence of which formula (17) requires refinement.

Table 10. Average for the V-VIII ratio of evaporation, wind speed and difference in the vapor pressures on main and supplementary areas in the day and night time.

	$E_0//E_д$	U_0/U_g	$(e_0-e)_0/(e_0-e)_д$
(1) Ночь	1,21	1,18	1,21
(2) День	1,11	1,15	1,00

Key: (1). Night. (2). Day.

Page 75.

Without having a possibility to demarcate the effect of elevation on the separate parameters, entering this formula, one correction, determined from the comparison of indications of same-type evaporators on main area and on the shore, where the effects of elevation, which was not manifested was produced.

Correction is determined average for entire evaporative season and is introduced into the coefficient of formula (17).

Formula after the introduction of correction takes the form:

$$E=0,22(e_0-e)(1+0,33U_2).n \qquad (18)$$

According to formula (18) are conducted at present the calculations of evaporation during the composition of monthly and annual water balances. The calculation of evaporation during the composition of heat balance was carried out according to the same formula.

Researchers, who were being occupied by the calculations of surface evaporation Lake Sevan, defined it as average, without examining the special features of the individual parts of Sevan lake. However, according to the nature of the hydrometeorological elements, which determine evaporation of lake nonhomogeneously. Thus, in Small Sevan the wind speed on the average in the year, is approximately to 10%, and in summer (VI-IX) is 20-30% higher than in the Large Sevan. At the same time the differences in the temperature of the surface layer of water in these parts of the lake are insignificant. Differences in the humidity of air above the lake are insignificant. It is natural that under such conditions the high wind speeds above small Sevan must lead to the more considerable evaporation. Actually, calculations according to formula (18) show that in the course of the 4th summer months (June - September) the evaporation in Small Sevan is approximately to 14% more than in the Large.

Material is given for the comparison of evaporation in Small and Large Sevan, and observation on water-evaporative areas even by the standard evaporators GGI-3000 seems interesting to us. It is obvious, of course, that the comparison of the values of evaporation on such evaporators, located on different distance from the lake, cannot characterize real differences in the evaporation from its surface.

Page 76.

And if we consider the factors, which determine evaporation, and the

special feature of the position of evaporators, this comparison can be useful.

In the Sevan Basin since 1957 acts the water-evaporative area of III discharge at Martuni station, equipped with evaporator GGI-3000. It is located at a distance of approximately 2 km from the lake in its southern part in the open plane locality. Observations on this area allows the possibility to conduct some comparisons with the data on the same-type evaporator in Sevan peninsula, arrangement of which has already been discussed.

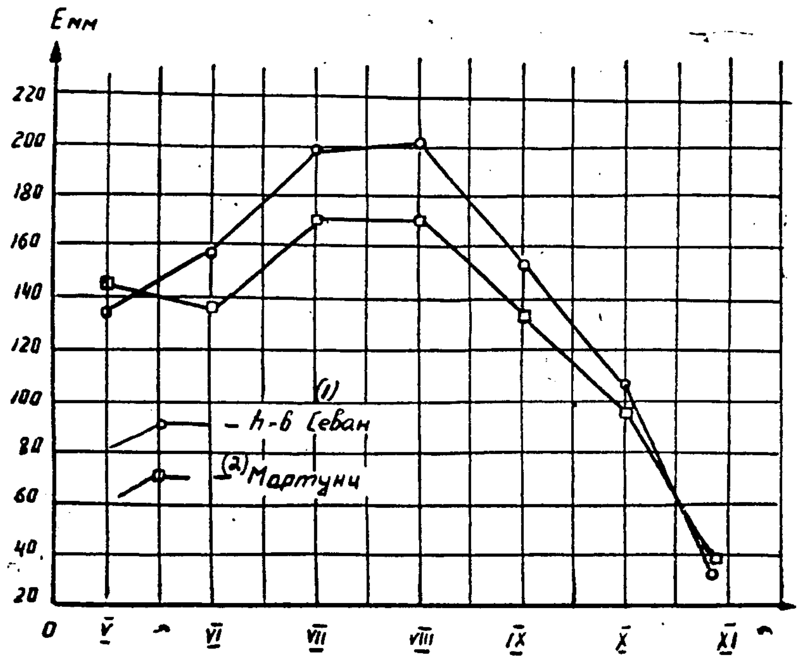

Fig. 7. - seasonal behavior of evaporation in Martuni and Sevan peninsula (observational data according to evaporator GGI-3000 in 1957-60 yr.).

Key: (1). Sevan. (2). Martuni.

Page 77.

Fig. 7 shows the distribution of the monthly sums of evaporation in Sevan peninsula, also, in Martuni during the evaporative season (May-November), averaged during the period 1957-1960. In both cases the evaporation was measured by evaporators GGI-3000.

Attention is drawn to the following special feature, during June - September the evaporation in the peninsula was noticeably more than in Martuni. Differences are especially great during July-August, when

they compose 15-17% of monthly value of evaporation in Martuni.

In other months of difference are less considerable. In October-November the evaporation in Martuni was approximately the same as in the peninsula, while during May even greater.

Differences in the value of evaporation on these evaporative areas are explained by the fact that wind speed in the peninsula during entire evaporative season is considerably higher than in Martuni.

The given differences in the evaporation cannot, of course, characterize the real ratio of the values of the evaporation of the northern and southern parts of the lake, since areas are located at different distance from the lake, and main area in the peninsula can not at all be considered as the completely representative.

Therefore were compared data on the evaporation on supplementary coast area in the peninsula with the data of Martuni station (see Table 11).

Table 11. Monthly sums of evaporation on supplementary area in the peninsula and in Martuni (mm).

	(a) Май			(b) Июнь			(c) Июль			(d) Август			(e) Сентябрь			(f) Октябрь		
	19-7	7-19	Σ	19-7	7-19	Σ	19-7	7-19	Σ	19-7	7-19	Σ	19-7	7-19	Σ	19-7	7-19	Σ
(1) П-ов	46	78	124	58	82	140	63	81	144	78	99	177	56	79	135	41	62	103
(2) Мар-туни	60	98	158	56	76	132	62	66	128	65	70	135	58	75	133	46	56	102

Key: (a). May. (b). June. (c). July. (d). August. (e). September. (f). October. (1). Peninsula. (2). Martuni.

Page 78.

Comparison shows that also on supplementary area in the peninsula in the summer time the evaporation is also greater than in Martuni, although difference less considerable. Should be considered still the circumstance that the area of Martuni station is located further from the lake. It is obvious that in the case, when these evaporators would be located in the identical conditions, differences in the evaporation could be somewhat more. And even in the examined case during June - September in the peninsula evaporation on the average is up to 12% more than in Martuni. The evaporation in these two points is approximately equal in the night time, whereas in the daytime in the peninsula evaporates noticeably the larger layer of water, especially during July and August.

The nature of the wind in the northern and southern parts of Lake Sevan, calculations of evaporation and comparison of observational data according to the evaporators give grounds to consider that in the southern part of greater Sevan the evaporation in the summer time is approximately 10-15% less than in the northern part of Small Sevan.

If we proceed from the distribution of hydrometeorological elements over the surface of lake, which sufficiently is well investigated, it is possible to assume that the variability of evaporation in the water area of large Sevan is comparatively small,

and in Small Sevan in its southern part the evaporation somewhat less than in north.

Calculations of the annual sum of surface evaporation of Lake Sevan in terms of average values of meteorological elements with the aid of different formulas obtained above gave very close results. Thus, according to formula (18) average annual sum of evaporation during the period of 1951-60 is equal to 838 mm, according to the formula, brought out in IVP-835 by mm.

Page 79.

b) the diffusion method:

1. the formula of GGO $E=7.5\cdot a_1\cdot u_1(e_0-e)\cdot n$ (19)

where a_1 - variable coefficient, depending on wind speed, the parameter of roughness and temperature stratification:

2. the formula, produced on IVP by A. M. Mkhitaryan

$$E=0.133\ U\ (e_0-e)\ n \qquad (20)$$

also gives close results - 859 mm according to formula (19) and 838 mm according to formula (20).

All this once more confirms sufficiently obvious position about the fact that the reason for differences in the value of evaporation in the different authors lies not in the structure of formulas, but in errors in the values of the meteorological elements, entered into the calculation.

Let us examine the special features of surface evaporation of lake, after using data of calculation.

Fig. 8 shows the annual variation of evaporation in small and large Sevan. It is identical for both parts of the lake.

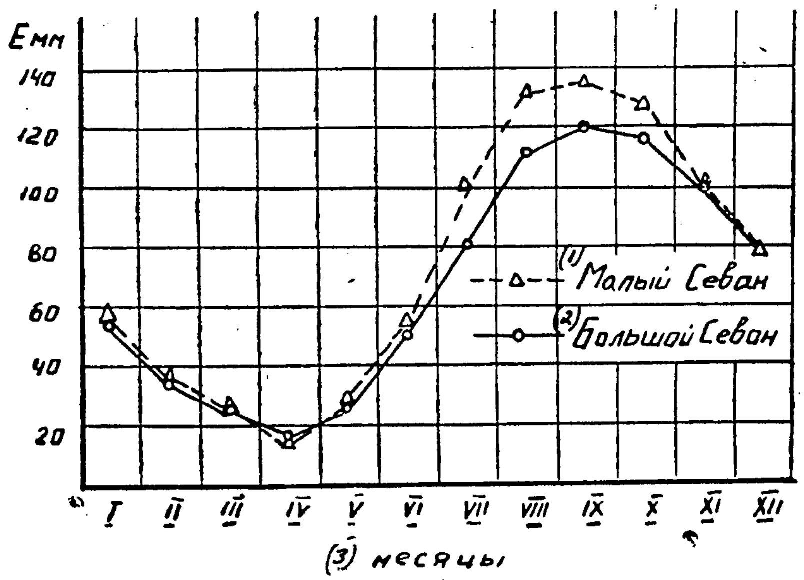

Fig. 8. - the annual variation of surface evaporation of small and large Sevan.

Key: (1). Small Sevan. (2). Large Sevan. (3). months.

Page 80.

Differences are only in the value of evaporation in the summer months, when the surface of Small Sevan in view of reasons examined above evaporates on the average to 13-14% more than the surface of Large Sevan. These differences are manifested also in the annual sum, which for small Sevan is approximately to 10% higher than for the large.

Estimating the effect of the decrease of a volume of the water mass of lake on the value of evaporation, it is possible to note the following: the decrease of a volume of water mass at present leading to the fact that the lake more frequently began to freeze. Within the

period from 1949 through 1959 the lake froze 5 times (1949, 1950, 1954, 1957, 1959 yr). In those years, when stable ice formation is observed, the annual variation of evaporation somewhat is changed. The evaporation from ice or snow is so insignificant in the period of ice formation (February-March) which virtually can be disregarded.

Due to this the annual value of evaporation in iced years is up to 5-10% less than into the non iced years.

In those years, when the lake freezes, the heating of the surface of water occurs with a certain delay. Therefore during May in these years evaporation is usually insignificant, and sometimes are created such conditions, with which even on the average in the month occurs the condensation (1954 Small Sevan). A noticeable change in the evaporation in the summer-autumn period of freezing years it is not observed. .

Thus during the first stage of the descent of lake, until substantial changes in its thermal mode yet occurs, ice formation leads to the decrease of the annual sum of evaporation.

6. Heat exchange in the water.

The significant part of the radiation heat, which enters the water surface, is spread in depth under the action of the processes of mixing, causing an increase in the temperature of water in the lake.

Page 81.

Accumulated thus heat is consumed by lake in autumnal and winter periods, again proceeding to water surface under the action of thermal convection and dynamic mixing. Accumulation and heat consumption is evinced by lake of a change in the enthalpy of its water mass.

Enthalpy most simply and reliably is determined according to the data of the measurement of the vertical distribution of the temperature of water in different parts of the lake, if in this case the specified conditions are observed. Thus, author [1] proposed the method of determining the enthalpy of water mass od Lake Sevan, which is reduced to the following.

1. Lake conditionally is subdivided into the regions:
a) with depths of up to 25 m (coastal),
b) with depths of 25-35 m,
c) with depths of 35-50 m,
d) with depths are more than 50 m (deep-water),
e) the region of the "dome of cold waters" in Large Sevan.

To each of these regions relate the specific hydrological vertical lines.

2. According to the observational data on each vertical line is constructed the profile of the vertical temperature distribution, with the aid of which by planimetry is determined average temperature on

the vertical line.

3. By averaging the obtained temperatures for the vertical lines, entering one region, is determined average temperature of region.

4. Multiplying average temperature of region upon a volume of its water mass and accepting the heat capacity equal to 1, we will obtain enthalpy in the water mass of region. The enthalpy of lake is obtained by the simple addition of enthalpy in the separate regions.

The volume of region (V_p is obtained with the aid of the hypsometric curve by the very simple correlation

$$V_p = \Sigma V_{\text{в-н}} + (S_{\text{в}} - S_{\text{н}}) H_{\text{в}} - S_{\text{н}} (H_{\text{н}} - H_{\text{в}} \qquad (21)$$

Page 82.

Here $\Sigma V_{\text{в-н}}$ - volume between the upper and lower limit of the depths of this zone;

$S_{\text{в}}, S_{\text{н}}$ - area of isobath on the upper and lower limits of the depths of region respectively;

$H_{\text{в}}, H_{\text{н}}$ - depth of the upper and lower limits of region respectively.

The method indicated is calculated separately for enthalpy of Small and Large Sevan at the end of each month within the period of 1951-60 (see Table 6. of Appendix).

Estimating the reliability of values of enthalpy obtained in this case, it should be noted that in the first years (1951-1955 yr) during their determination the considerable errors could be allowed. In these years insufficiently in detail was studied the verticle temperature distribution.

Furthermore, the periods of the carrying out of observations on the vertical lines (on the dates and on the time of day), which led to the supplementary errors, were not always maintained. Everything stated relates, first of all, to Large Sevan, where the most considerable errors in the determination of enthalpy due to this could be allowed.

The materials of the subsequent years are more reliable, since very detailed measurements at the depths were made at this time, in essence, the periods of the carrying out of observations were maintained, observations for each of the vertical line were conducted, as a rule, at one time of day, which made it possible more reliably to determine a change in average temperatures.

In spite of possible errors, the calculation of heat-supply by the method according to the data of the measurements of the temperature of water indicated gives the total most objective evaluation of the thermal condition of lake, which does not depend on the accuracy of the determination of income and expenditure of heat.

A change in the enthalpy can be determined, without conducting the measurements of temperature at the depths - on the known radiation balance, to the meteorological characteristics of air above the basin (temperature, humidity, the wind) and to the temperature of water on the surface of lake.

Page 83.

Formula for calculating the change in the enthalpy (B) in this case takes the form:

$$B=R-\frac{U_1[L(q_0-q)+C_p(\Theta_w-\Theta]}{\overline{U_1[L(q_0-q)+C_p(\Theta_w-\Theta)]}}\overline{R} \qquad (22)$$

or, after reduction to the usually measured values and the height of Sevan lake.

$$B=R-\frac{U_1[0,47(e_0-e)+0,24(\Theta_w-\Theta)]}{\overline{U_1[0,47(e_0-e)+0,24(\Theta_w-\Theta)]}}\cdot\overline{R} \qquad (23)$$

Here $\overline{R}, \overline{U_1}, \overline{(e_0-e)}, \overline{(\Theta_w-\Theta)}$ - average values of radiation balance, speed of wind, sizes of vapor pressures, difference in temperatures of water and air for natural cycle or as this usually is accepted, for year; the same designations without the indices of averaging characterize the values of the given parameters during the period, for which it is determined by B.

A change in the enthalpy is determined in this case depending on others components of heat balance; the accuracy of calculation depends on the accuracy of all entering formulas (23) parameters and first of

all from R and $\bar{R}$.

As it follows from the structure of formula (23), the greatest relative errors during the calculation of heat exchange by the method indicated can occur in the period of transition from heating of water mass to the cooling and vice versa, when the first and second member of the right side of formula (23) are little distinguished by the value.

In these cases even insignificant errors during the determination of radiation balance and meteorological elements can lead to the error in the sign of heat exchange.

So for example, during March of 1953 the cooling water mass in small and large Sevan, fixed by the measurements of temperature on all hydrological vertical lines, occurred.

Page 84.

The temperature in the conditions of homothermy was lowered on all vertical lines by 0.2-0.5°.

However, calculation according to formula (23) showed an increase in the enthalpy in the course of this month, which, of course, does not correspond to reality. The errors of the same nature, are less noticeable and indisputable, are encountered in the separate years in the beginning of spring period.

It is necessary to note that in the presence of noticeable advection the method of calculating the heat exchange in the water according to weather data proves to be unsuitable, since it is based on the assumption about the fact that the advective term in the equation of heat balance is absent. At the same time calculation according to the weather data has the definite advantages.

1. During the determination of an annual change in its heat-supply one should determine on the measurements of temperature, since calculation according to the weather data in these cases gives large errors.

2. A change in the enthalpy during the monthly period during the application of any of the methods indicated is calculated with the sufficiently considerable errors, was impossible to evaluate.

3. Under the conditions of homothermy, more preferably calculated is change in the enthalpy according to the data of the measurement of temperature on the hydrological vertical lines, since in this case the errors of this method are insignificant.

4. In the presence of advection one ought not to determine heat exchange according to the weather data, since this is connected with the systematic errors, which depend on the value of advection.

5. In the insufficiently detailed measurements of the vertical profile of temperatures the determination of heat exchange according to the measurement data is connected with the large errors, in connection with which in these cases to more preferably determine it according to the weather data.

Page 85.

Calculations according to the weather data can serve for the adjustment of the monthly values of the heat exchange, calculated according to the observational data, when in the measurement of temperature dates and periods were not maintained.

The annual variation of enthalpy can be characterized as follows.

The cooling of lake begun with autumn ceases usually in the beginning of second half of March in 1-2 weeks to the transition of the temperature of air through 0°. With delayed winters this period can move to the very end of March or the first days of April. Average temperature of lake in the period of the greatest cooling somewhat lower than 2°. In the cold winters it descends to 1.5°-1.7°. (at this temperature occurs freezing of lake), into warm - approaches 3°.

The heating of lake begins from second half of March. It more intensely occurs in Large Sevan, since depths are there less.

The most intense increase in the enthalpy of water mass occurs

during May. In the period of heating the significant part of the heat, which enters the surface of lake, is consumed on heating of water (from 74% to 83% of radiation balance).

An increase in the enthalpy continues usually to the end of August. At this time average temperature in shallower Large Sevan reaches 14°, in Small - comprises on an average 11.5°.

Cooling water mass begins during September and reaches the greatest intensity during November. The water mass is cooled more slowly in proportion to heat emission. The temperature of the greatest water density reaches only during January.

Table 12 shows average temperatures of water at the end of each month, averaged for 1951-60 (1954, 1957 and 1959, into which it was observed ice formation, during the determination of temperature in February-March were not considered).

Table 12 Mean temperature of the water mass of small and large Sevan at the end of the month

	I	II	III	IV	V	IV	VII	VIII	IX	X	XI	XII
Small Sevan	2,79	2,22	2,29	3,43	6,25	8,80	10,60	11,54	11,00	9,33	6,81	4,55
Large Sevan	2,83	2.19	2,59	4,32	7,97	10,78	12,83	13,95	13,24	10,97	7,73	4,72

7. Complete heat balance Lake. Sevan.

After examining fundamental component of heat balance of Lake Sevan and the nature of a change in the enthalpy of water mass, it is possible to compose complete heat balance of lake and its individual parts in accordance with equation (1). It is necessary to keep in mind that the components of heat balance in each month of 1951-60 were

calculated independently of each other, in connection with which complete heat balance will make possible to indirectly evaluate the accuracy of these calculations.

Page 86.

Were preliminarily examined monthly and annual heat balance for 1951-60, which were comprised for the water mass of Small and Large Sevan (into 10^{12} k/kal). During the composition of balances in the separate months was not considered the admission of heat with the inflows and its consumption in connection with the decrease of a volume of the water mass, which, as it was shown, in the sum compose less than 1% annual radiation balance. The accuracy of these heat balance, as a rule, are small (discrepancy error in the separate months reaches 25-30%) in the summer months upon consideration advection of discrepancy error noticeably decrease (they do not exceed 5%).

The need for the account of advection becomes even more obvious during the analysis of the annual heat balance, which are considerably more reliable than monthly.

Page 87.

Thus, if we do not consider advection, in Small Sevan the heat balance in the year always has the negative discrepancy error (heat consumption of larger arrival), in the Large - positive and considerably greater in the absolute value. The presence of the stable discrepancy error of opposite sign in the heat balance of the

individual parts of the lake is the sufficiently convincing proof of the existence of advection and need for its account. The discrepancy error in the annual heat balance of small and large Sevan is positive upon consideration of advection and it is approximately identical with respect to the value (it does not exceed 5-6%).

It is understandable that the many-year heat balance for entire volume of the water mass of Small and Large Sevan cannot be comprised, since the volume of lake constantly decreases (approximately on 1 km^3 per annum). Therefore average for 1951-60 complete heat balance was examined for the vertical column with a surface area of 1 cm^2.

Radiation balance (R) is accepted in accordance with the data of the table of 4 appendices; the monthly values of turbulent heat exchange (P) are calculated according to formula (12) with the use of average monthly temperatures of air, water and speed of wind (Table 1, 5, 3 Appendices). The value of evaporation (E) was determined from formula (18); as the parameters are accepted the average monthly values of absolute humidity (Table 2 of appendix), speed of wind (Table 3 of Appendix) and maximum vapor pressure , which was determined by the average monthly temperature of water (Table 5 of Appendix).

A change in the enthalpy (heat exchange in the water) was determined by other means. In connection with the fact that the heat-supply was calculated as a whole for the water mass of Small and

Large Sevan, and mass itself from one year to the next decreases, a change in the enthalpy in all months of the given year was divided into area of water surface average in this year. Obtained thus values of heat exchange for the column were averaged in 10 years for each month (B) and then they were used for the composition of complete heat balance.

Page 88.

Heat advection through the spill (F) is accepted in accordance with [2] equal to 30×10^{12} to kcal and then is related to the unit of area in Small and Large Sevan.

The cumulative effect of the heat losses due to the decrease of the volume of water mass and admission of heat with inflows (ΣB_{u}). is also taken into consideration.

Heat consumption in this case exceeds admission, in connection with which the lake yearly loses approximately 8×10^{12} the kcal. This value is related to the unit of area.

Comprised thus the complete heat balance of Small and Large Sevan is shown in Table 13. Discrepancy of error is calculated both in the absolute values (H) and percentages.

Errors in the monthly heat balance, as a rule, are small (from 0 to 5-7%); considerable discrepancies errors occur during April and

November in Small Sevan (14 and 13%) and during February, April and October in Large (10, 18 and 11%). In connection with the fact that in the monthly balances the discrepancies errors of one sign (positive) prevails, heat balance in the year in Small and Large Sevan has errors, which for the 10-year period of averaging are inadmissibly great (5%). This verifies the presence of a systematic error and makes it necessary to thoroughly evaluate possible errors during the calculation of separate components of heat balance.

Radiation balance, as it was shown above, was calculated with a sufficient accuracy (its errors in the separate years do not exceed 3%, which with the averaging in 10 years eliminates considerable errors). An annual change in the enthalpy is determined according to the data of the measurements of the temperature in the conditions of homothermy to bottom (end of December) which also eliminates the presence of considerable errors. True, an annual change in the enthalpy is not equal to 0, as must be with the averaging for many years duration, and this is explained by the large variability of the value of heat-supply in the periodically freezing lake. Actually, heat-supply of Lake Sevan at the end of December oscillates from 284×10^{12} kcal (December 1952) to 137×10^{12} kcal (December 1953).

Page 89.

Table 13. The heat balance (kcal/cm²) of Small and Large Sevan (1951-60 yr.).

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	(b) Год
(a) Малый Севан													
R	0·3	2·2	4·7	9·4	12·4	12·7	12·9	11·2	7·1	3·3	0·0	-0·9	75·3
LE	3·6	2·2	1·6	0·9	1·1	3·3	6·0	7·8	8·1	7·7	5·9	4·7	52·9
P	4·6	3·4	2·1	-0·4	-0·9	0·3	1·1	1·3	2·0	2·2	3·3	4·9	23·9
B	-7·9	-3·7	1·3	7·5	12·6	11·3	8·1	3·5	-3·1	-7·0	-10·6	-10·0	2·0
F					-0·6	-2·2	-3·1	-2·0	-0·5				-8·4
$\Sigma B_м$													0·6
H	0·0	0·3	-0·3	1·4	0·2	0·0	0·8	0·6	0·6	0·4	1·4	-0·5	4·3
%	0	5·3	6	14	2	0	5	5	6	4	13	5	5
(c) Большой Севан													
R	0·4	2·0	4·8	9·7	12·4	13·1	13·0	11·5	7·7	4·2	0·6	-1·0	78·4
LE	3·2	2·1	1·6	1·0	1·6	3·2	5·0	6·8	7·3	7·0	5·9	4·6	49·3
P	4·0	2·7	1·6	-0·6	0·0	0·1	0·1	0·5	1·7	1·9	3·2	4·5	19·7
B	-6·5	2·3	1·5	7·4	10·4	8·6	6·5	3·5	-2·1	-5·8	-9·2	-9·9	2·1
F					0·2	0·8	1·1	0·7	0·3				3·1
$\Sigma B_м$													0·6
H	-0·3	-0·5	0·1	1·9	0·2	0·4	0·3	0·0	0·5	1·1	0·7	-0·2	3·6
%	4	10	2	18	2	3	2	0	5	11	7	2	5

The note: In Table 13 annual discrepancy error is not equal to the sum of monthly discrepancy error, since the total heat losses due to the decrease of volume of water mass were considered as complete for the year.

Key: (a). Small Sevan. (b). Year. (c). Large Sevan.

Page 90.

The greatest errors could be allowed during the calculation of turbulent heat exchange and evaporation in connection with the fact that wind speed, on which was conducted the calculation, was understated to 6-10%. Assuming that on the average the wind speed, given in Table 3 of Appendix, is understated to 8%, to introduce this

correction into its average monthly values and on thus such to speeds to calculate turbulent heat exchange and evaporation, then complete heat balance of lake and its individual parts for the entire year can be represented in the form of the following table (see Table 14).

The heat balance of entire lake, shown in Table 14, is comprised taking into account the areas of Small and Large Sevan.

The annual value of evaporation (norm of evaporation) from the surface of Lake Sevan in the last decade (1951-60) according to the method of heat balance was obtained equal to 872 mm. The previously calculated annual sums of evaporation according to the formulas of hydrometeorological method and method of turbulent diffusion are lower than this value (on 13-37 mm), which is explained, first of all, by errors in wind speed, used during calculations.

The smallest differences with the heat balance gives calculation according to formula (19).

Table 14. Complete heat balance of Lake Sevan and its individual parts (kcal/cm² year).

(a)Составляющие баланса	R	LE	P	B	F	$\Sigma B_м$	H
(1)Малый Севан	75,3	55,1	25,8	2,0	—8,4	0,6	0,2
(2)Большой Севан	78,4	51,2	21,3	2,1	3,1	0,6	0,1
(3)Все озеро	77,5	52,3	22,6	2,0		0,6	0,0

Page 91.

It is obvious that calculation according to the formulas of hydrometeorological method and method of turbulent diffusion during the use of values of wind speed from table 3 will give somewhat understated annual values of correction. On the other hand, the heat balance can have some errors, which it is impossible to consider here. Therefore as the norm of evaporation for 1951-60 it is possible to accept average from the values, obtained according to the hydrometeorological method and the method of heat balance. Thus, the average annual value of surface evaporation of Lake Sevan as of 1951-60 is accepted equal to 855 mm. Possible errors in the norm of evaporation accepted are within the limits ±20 of mm.

In conclusion it should be noted that the obtained norm of evaporation is close to the value, obtained by V. K. Davydov for 1926-30 (835 mm), and confirms those expressed by it the consideration about evaporation change in connection with the decrease of a volume of the water mass of lake.

Page 92.

REFERENCES.

1. Айнбунд М. М. К вопросу о термическом режиме оз. Севан. Результаты комплексных исследований по Севанской проблеме, т. 1, АН Арм. ССР, 1961.

2. Айнбунд М. М. Об особенностях термического режима в проливе между Малым и Большим Севаном. Известия АН Арм. ССР, науки о земле, XVII, № 1, 1964.

3. Браславский А. П., Викулина З. А. Нормы испарения с поверхности водохранилищ, Гидрометоиздат, 1954.

4. Будыко М. И., Берлянд Т. Г., Зубенок Л. И. Методика климатических расчетов составляющих теплового баланса, труды ГГО, вып. 48 (110), 1954.

5. Будыко М. И. Тепловой баланс земной поверхности. Гидрометиздат, 1956.

6. Давыдов В. К. Испарение с поверхности оз. Севан. Материалы по исследованию оз. Севан и его бассейна, ч. II, вып. 2, 1935.

7. Давыдов В. К. Водный баланс оз. Севан. Материалы по исследованию оз. Севан и его бассейна, ч. VI, 1938.

8. Кириллова Т. В., Тимофеев М. П. О расчете радиационного баланса водоемов по радиационному балансу суши. Метеорология и гидрология, № 11, 1959.

9. Кузьмин П. П. Теплоотдача моря в воздух путем конвекции. Метеорология и гидрология, № 2, 1938.

10. Мхитарян А. М., Александрян Г. А., Атаян Э. А. Водный баланс оз. Севан. Результаты комплексных исследований по Севанской проблеме, т. I АН Арм. ССР, 1961.

11. Самойленко В. С. Формирование температурного режима морей. Гидрометеоиздат, 1959.

12. Тимофеев М. П., ред. Метеорологический режим оз. Севан, Гидрометоиздат, 1960.

Page 93.

Table 1. APPENDICES. Average monthly temperature of air above Lake Sevan (°C).

(a) Год	(b) Месяцы	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	(c) год
1951	(1) М. Севан	—4,7	—4,5	1,2	5,4	9,1	13,3	17,0	17,1	13,4	7,3	4,2	—2,7	6,3
	(2) Б. Севан	—4,1	—4,2	2,2	6,1	9,9	13,5	17,1	17,1	13,6	7,9	4,7	—1,5	6,9
	(3) Все озеро	—4,3	—4,3	1,9	5,9	9,6	13,4	17,1	17,1	13,5	7,7	4,6	—1,8	6,7
1952	М. Севан (1)	—3,7	—1,9	—1,2	3,4	7,9	11,3	15,9	16,8	14,6	12,7	4,3	—0,2	6,7
	Б. Севан (2)	—3,0	—0,7	—0,2	4,4	8,5	12,0	16,5	17,1	14,6	12,8	4,5	0,6	7,3
	Все озеро (3)	—3,2	—1,1	—0,5	4,1	8,4	11,8	16,3	17,0	14,6	12,8	4,5	0,3	7,1
1953	М. Севан (1)	—2,2	—1,8	—3,0	3,8	9,2	13,3	15,6	17,1	13,5	10,0	4,0	—6,4	6,1
	Б. Севан (2)	—1,7	—0,8	—1,9	4,8	9,4	13,6	15,6	17,1	13,8	10,5	2,1	—5,9	6,4
	Все озеро (3)	—1,9	—1,1	—2,2	4,5	9,4	13,3	15,6	17,1	13,7	10,4	2,7	—6,0	6,3
1954	М. Севан (1)	—5,7	—7,4	—3,7	2,5	7,3	12,8	16,7	17,6	14,0	11,3	5,4	0,2	6,8
	Б. Севан (2)	—4,4	—7,0	—3,0	3,3	8,6	13,5	16,8	17,5	14,3	11,3	5,6	0,6	7,0
	Все озеро (3)	—4,8	—7,1	—3,2	3,1	8,2	13,2	16,8	17,5	14,2	11,3	5,5	0,5	6,9
1955	М. Севан (1)	—2,0	0,6	0,7	5,2	9,3	14,0	16,4	16,2	13,8	11,4	5,2	—1,4	7,4
	Б. Севан (2)	—1,6	1,3	1,3	6,0	10.1	14,4	16,7	16,5	13,8	11,1	5,6	—0.1	7,9
	Все озеро (3)	—1,7	1,1	1,1	5,8	9,9	14,3	16,6	16,4	13,8	11,2	5,5	—0.5	7,7

Key: (a). Year. (b). Months. (c). year. (1). S. Sevan. (2). L. Sevan. (3). Entire lake.

Page 94.

Cont. of Table 1.

1956	(1) М. Севан	—3,8	—1,8	—2,9	3,2	6,2	12,2	15,4	16,9	11,8	19,4	2,7	—4,9	5,4
	(2) Б. Севан	—2,8	—0,7	—2,0	3,7	7,3	12,7	15,7	16,8	11,8	93	3,7	—4,5	5,9
	(3) Все озеро	—3,1	—1,0	—2,3	3,6	7,0	12,6	15,6	16,9	11,8	9,3	3,4	—4,7	5,7
1957	М. Севан (1)	—7,5	—8,6	—2,0	4,7	8,2	12,6	15,5	17,2	15,9	10,4	4,4	—1,3	5,8
	Б. Севан (2)	—7,3	—8,5	—0,8	5,0	8,9	12,6	15,4	16,8	15,4	10,5	4,9	—1,0	6,0
	Все озеро (3)	—7,3	—8,5	—1,2	4,9	8,7	12,6	15,4	17,0	15,6	10,5	4,7	—1,1	5,9
1958	М. Севан (1)	—2,1	—2,3	1,0	4,2	9,5	13,5	15,2	16,2	13,2	9,6	3,3	—2,2	6,6
	Б. Севан (2)	—1,2	—1,6	1,9	4,7	9,8	13,7	15,3	16,2	13,3	9,6	3,4	—2,1	6,9
	Все озеро (3)	—1,4	—1,8	1,6	4,6	9,7	13,6	15,3	16,2	13,3	9,6	3,4	—2,2	6,8
1959	М. Севан (1)	—2,6	—7,0	—3,4	5,4	8,1	12,5	16,1	15,5	11,9	8,0	3,9	—1,9	5,8
	Б. Севан (2)	—2,0	—6,2	—2,9	5,0	8,7	13,0	16,3	15,6	12,3	8,5	3,9	—1,7	5,9
	Все озеро (3)	—2,,2	—6,4	—3,0	5,1	8,5	12,9	16,2	15,5	12,2	8,4	3,9	—2,3	5,8
1960	М. Севан (1)	—2,4	—1,6	—2,3	3,1	9,6	13,2	15,2	15,4	13,9	11,1	5,4	0,3	6,7
	Б. Севан (2)	—1,6	—0,7	—1,9	4,1	10,5	13,6	15,3	15,5	14,0	11,1	5,5	0,5	6,9
	Все оезро (3)	—1,8	—1,0	—2,0	3,8	10,3	13,5	15,3	15,4	14,0	11,1	5,5	0,4	6,8
(4) Средне-	М. Севан (1)	—3,7	—3,6	—1,6	4,1	8,4	12,9	15,9	16,6	13,6	10,1	4,3	—2,0	6,6
много-	Б. Севан (2)	—3,0	—2,9	—0,7	4,7	9,2	13,3	16,1	16,7	13,7	10,3	4,4	—1,5	6,7
летнее	Все озеро (3)	—3,9	—3,1	—1,0	4,5	9,0	13,1	16,0	16,7	13,7	10,2	4,4	—1,7	6,7

Key: (1). S. Sevan. (2). L. Sevan. (3). Entire lake. (4). Average perennial.

Page 95.

Table 2. Average monthly absolute humidity above the water area of Lake Sevan (mb.).

(a) Год	(b) Месяцы	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Год (a)
1951	(1) М. Севан	3,5	4,0	5,3	6,8	8,9	11,0	14,0	13,0	10,9	7,1	6,1	4,1	7,9
	(2) Б. Севан	3,4	4,0	5,5	6,8	8,8	10,9	13,8	12,8	10,7	7,1	5,9	4,0	7,8
	(3) Все озеро	3,4	4,0	5,4	6,8	8,8	10,9	13,9	12,9	10,8	7,1	6,0	4,0	7,9
1952	М. Севан (1)	3,7	4,3	4,4	6,7	8,4	10,7	13,2	12,4	10,6	8,5	5,6	5,0	7,8
	Б. Севан (2)	3,8	4,4	4,4	6,6	8,4	10.8	13,1	12,4	10,6	8.5	5.6	5,0	7,8
	Все озеро (3)	3.8	44,	4,4	6,6	8,4	10,8	13,1	12,4	10,6	8,5	5.6	5,0	7,8
1953	М. Севан (1)	3,9	4,1	3,9	6,8	8,7	11,4	14,0	13,8	10,1	7,9	4,6	2,9	7,7
	Б. Севан (2)	4,0	4,1	4,0	6,8	8,5	11,4	14,1	13,8	9,8	7,9	4,8	3,3	7,7
	Все озеро (3)	4,0	4,1	4,0	6,8	8,5	11,4	14,1	13,8	9,9	7,9	4.8	3,2	7,7
1954	М. Севан (1)	3,2	3,2	4,4	6,0	8,7	11,6	13,8	13,6	11,6	7,6	6,2	5,0	7,9
	Б. Севан (2)	3,4	3,2	4,4	6,2	8,7	11,5	13,7	13,6	11,6	7,6	6.1	4,9	7,9
	Все озеро (3)	3,4	3,2	4,4	6,1	8,7	11,5	13,7	13,6	11,6	7,6	6,1	4,9	7,9
1955	М. Севан (1)	4,9	4,6	5,1	6,6	9.4	12,1	13,3	13,3	11,4	8,2	5,9	4,5	8,3
	Б. Севан (2)	4,9	4,6	5,0	6,7	9,3	12,1	13,3	13,4	11,2	8,2	5,9	4,5	8,3
	Все озеро (3)	4,9	4,6	5,0	6,7	9,3	12,1	13,3	13,4	11,2	8,2	5,9	4,5	8,3

Key: (a). Year. (b). Months. (1). S. Sevan. (2). L. Sevan. (3). Entire lake.

Page 96.

Cont. of Table 2.

1956	(1) М. Севан	3,6	4,3	3,9	6,2	7,6	11,2	13,3	12,9	9,2	6,2	4,5	3,4	7,2
	(2) Б. Севан	3,6	4,2	3,9	6,2	7,5	11,2	13,6	13,0	9,3	6,1	4,8	3,4	7,2
	(3) Все озеро	3,6	4,2	3,9	6,2	7,5	11,2	13,5	13,0	9,3	6,1	4,7	3,4	7,2
1957	М. Севан (1)	2,9	3,3	4,6	6,3	8,9	11,1	13,3	13,3	11,5	7,3	5,7	4,3	7,7
	Б. Севан (2)	2,9	3,1	4,6	64,	8,7	11,1	13,2	13,3	11,5	7,3	5,7	4,3	7,7
	Все озеро (3)	2,9	3,2	4,6	6,4	8,8	11,1	13,2	13,3	11,5	7,3	5,7	4,3	7,7
1958	М. Севан (1)	4,3	3,8	5,1	6,0	8,9	11,4	12,9	12,8	10,1	6,9	4,8	4,3	7,6
	Б. Céван (2)	4,3	3,8	5,1	6,0	8,9	11,4	12,9	12,8	10,1	6,8	4,8	4,3	7,6
	Все озеро (3)	4,3	3,8	5,1	6,0	8,9	11,4	12,9	12,8	10,1	6,8	4,8	4,3	7,6
1959	М. Севан (1)	3,9	2,4	4,3	6,2	9,5	11,5	13,8	13,6	9,3	7,0	5,9	4,2	7,6
	Б. Севан (2)	4,0	2,5	4,3	6,2	9,5	11,3	13,6	13,5	9,4	6,9	5,9	4,1	7,6
	Все озеро (3)	4,0	2,5	4,3	6,2	9,5	11,4	13,6	13,5	9,4	6,9	5,9	4,1	7,6
1960	М. Севан (1)	3,8	4,1	4,1	6,4	9,5	11,9	13,9	13,2	10,9	7,8	5,8	4,6	8,0
	Б. Севан (2)	3,9	4,3	4,2	6,5	9,5	11,9	13,9	13,2	10,9	7,8	6,0	4,7	8,1
	Все озеро (3)	3,9	4,2	4,2	6,5	9,5	11,9	13,9	13,2	10,9	7,8	5,9	4,7	8,1
(4) Средне-	М. Севан (1)	3,8	3,8	4,5	6,4	8,8	11,4	13,6	13,2	10,6	7,4	5,5	4,2	7,8
много-	Б. Севан (2)	3,8	3,8	4,5	6,4	8,8	11,4	13,5	13,2	10,6	7,4	5,6	4,3	7,8
летнее	Все озеро (3)	3,8	3,8	4,5	6,4	8,8	11,4	13,5	13,2	10,6	7,4	5,5	4,3	7,8

Key: (1). S. Sevan. (2). L. Sevan. (3). Entire lake. (4). Average perennial.

Page 97.

Table 3. Average monthly speed of wind (m/s) above the water area of Lake Sevan (height of 1.0 m).

(a) Год	(b) Месяцы	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	(a) Год
1951	(1) М. Севан	4,9	3,6	2,8	2,6	2,8	3,3	3,2	3,8	3,6	3,4	3,4	4,0	3,4
	(2) Б. Севан	4,5	3,4	2,8	2,4	3,1	3,0	2,8	2,9	3,0	3,4	3,6	3,9	3,2
	(3) Все озеро	4,7	3,5	2,8	2,5	3,0	3,1	3,0	3,1	3,1	3,4	3,5	3,9	3,3
1952	М. Севан (1)	4,2	4,0	4,1	2,9	2,8	2,9	3,2	3,2	3,0	2,9	3,6	3.6	3,4
	Б. Севан (2)	4,1	4,0	4,2	2,8	3,4	2,8	2,7	2,8	3,0	3,0	3,6	3,7	3,3
	Все озеро (3)	4,1	4,0	4,2	2,8	3,2	2,8	2,9	3,0	2,9	3,0	3,6	3,7	3,4
1953	М. Севан (1)	4,1	4,3	4,0	2,8	2,6	2,8	3,8	3,4	3,8	3,3	4,3	4,0	3,6
	Б. Севан (2)	4,3	4,4	3,8	2,8	2,4	2,5	2,8	2,8	3,0	2,8	4,0	3,6	3,3
	Все озеро (3)	4,2	4,4	3,9	2,8	2,5	2,6	3,1	3,0	3,2	3,0	4,1	3,7	3,4
1954	М. Севан (1)	4,8	3,0	2,4	3,0	2,6	3,4	3,2	3,3	3,6	2,8	3,2	3,7	3,2
	Б. Севан (2)	5,0	2,9	2,3	2,9	2,6	2,8	2,5	2,8	2,8	2,9	2,8	3,2	3,0
	Все озеро (3)	4,9	2,9	2,3	2,9	2,6	3,0	2,8	3,0	3,1	2,9	3,0	3,3	3,1
1955	М. Севан (1)	3,6	4,2	3,7	3,2	2,6	3,2	3,6	4,0	3,8	2,8	4,0	4,6	3,6
	Б. Севан (2)	3,2	4,0	3,3	3,0	2,5	2,6	3,0	3,0	2,8	2,8	3,8	4,4	3,2
	Все озеро (3)	3,3	4,1	3,4	3,1	2,5	2,8	3,2	3,3	3,1	2,8	3,9	4,5	3,3

Key: (a). Year. (b). Months. (1). S. Sevan. (2). L. Sevan. (3). Entire lake.

Page 98.

Cont. of table 3.

1956	(1) М. Севан	3,6	4,3	3,8	2,5	3,2	3,2	4,0	3,6	3,4	3,0	4,2	4,0	3,6
	(4) В. Севан	3,3	4,4	3,2	2,8	2,8	2,4	2,8	2,7	2,7	2,9	4,0	3,6	3,1
	(3) Все озеро	3,4	4,4	3,3	2,8	3,0	2,7	3,2	3,0	2,9	2,9	4,1	3,7	3,3
1957	М. Севан (1)	3,6	1,4	3,4	2,4	2,6	2,8	3,0	3,3	3,0	2,8	3,3	3,9	3,0
	(4) Б. Севан	3,0	1,2	3,2	2,2	2,4	2,3	2,3	2,6	2,5	2,8	3,4	3,8	2,6
	Все озеро (3)	3,2	1,3	3,3	2,3	2,5	2,4	2,5	2,8	2,6	2,8	3,5	3,8	2,8
1958	М. Севан (1)	4,0	4,2	4,2	3,4	2,8	2,8	3,6	3,8	3,8	3,7	3,4	3,5	3,6
	Б. Севан (4)	3,6	4,0	4,1	3,2	2,4	2,4	2,6	2,6	2,7	3,0	3,4	3,0	3,1
	Все озеро (3)	3,7	4,1	4,1	3,2	2,5	2,5	2,9	2,9	3,0	3,2	3,4	3,1	3,2
1959	М. Севан (1)	3,8	4,9	3,0	3,0	2,7	3,1	3,6	3,6	3,8	3,6	3,5	3,7	3,5
	Б. Севан (4)	3,3	4,6	2,2	3,0	2,3	2,4	2,5	2,5	2,3	3,2	3,2	3,2	2,9
	Все озеро (3)	3,4	4,7	2,4	3,0	2,4	2,6	2,9	2,9	3,1	3,3	3,2	3,3	3,1
1960	М. Севан (1)	4,2	4,0	3,6	3,2	2,8	3,0	3,1	3,7	3,7	3,2	3,4	3,0	3,4
	Б. Севан (4)	3,4	3,9	3,0	2,7	2,4	2,4	2,4	2,6	2,8	3,0	3,2	3,0	2,9
	Все озеро (3)	3,7	3,9	3,2	2,9	2,5	2,6	2,6	2,9	3,1	3,1	3,3	3,0	3,1
(5) Среднее	М. Севан (1)	4,1	3,8	3,5	2,9	2,8	3,0	3,4	3,6	3,6	3,2	3,7	3,8	3,4
много-	Б. Севан (4)	3,8	3,7	3,2	2,8	2,6	2,6	2,6	2,7	2,8	3,0	3,5	3,5	3,1
летнее	Все озеро (3)	3,9	3,7	3,3	2,8	2,7	2,7	2,9	3,0	3,0	3,0	3,6	3,6	3,2

Key: (1). S. Sevan. (2). L. Sevan. (3). Entire lake. (4). L. Sevan. (5). Average many-year.

Page 99.

Table 4. Radiation balance of Lake Sevan (kcal/cm² of matr.ces).

(a) Год	(b) Месяцы	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Год (a)
1951	(1) М. Севан	0,1	2,5	7,9	10,4	12,0	12,4	12,9	10,9	6,6	2,8	1,1	—0,9	78,7
	(2) Б. Севан	0,3	2,9	8,0	10,4	12.3	12,7	13,7	10,9	6,8	2,8	0,7	—1,0	80,5
	(3) Все озеро	0,2	2,8	8,0	10,4	12,2	12,6	13,4	10,9	6,7	2,8	0,8	—1,0	80,0
1952	М Севан (1)	0,2	3,2	6,9	10,0	12,9	12,2	12,8	11,0	7,6	3,8	—0,1	—0,3	80,2
	Б. Севан (2)	0,4	3,4	7,2	10,2	13,3	12,6	13,2	11,6	8,1	4,4	—0 2	—0,4	83,8
	Все озеро (3)	0,3	3,3	7,1	10,1	13,2	12,5	13,1	11,4	7,9	4,2	—0,2	—0,4	82,6
1953	М. Севан (1)	0,5	3,1	6,3	10,1	12,3	12,5	12,0	11,4	7,4	3,9	--0,4	—1,3	77,8
	Б. Севан (2)	0,2	3,2	6,6	9,7	12,2	12,9	12,5	12.2	7,9	4,2	0,1	—1,6	80,1
	Все озеро (3)	0,3	3,2	6,5	9,8	12,2	12,8	12,3	11,9	7,8	4,1	0,0	—1,5	79,3
1954	М. Севан (1)	0,3	—1,1	—1,5	9,9	12,8	13,2	13,3	11,6	7,0	3,6	0,3	—0,6	69,6
	Б. Севан (2)	0,5	—1,0	—1,4	9,5	12,6	13,3	13,3	12,2	7,5	4,4	0,8	—0,7	71,1
	Все озеро (3)	0,4	—1,0	—1,4	9,6	12,9	13,3	13,4	12,0	7,3	4,2	0,6	—0,7	70,6
1955	М. Севан (1)	0,6	3,2	7,0	10,3	12,0	12,9	12,4	10,4	7,1	3,4	0,1	0,2	79,6
	Б. Севан (2)	0,0	3,3	7,1	9,8	11,9	13,2	12,7	11,1	7,7	4,4	0,8	—0,7	81,3
	Все озеро (3)	0,2	3,3	7,1	10,0	11,9	13,1	12,6	10,9	7,5	4,1	0,6	—0,4	80,8

Key: (a). Year. (b). Months. (1). S. Sevan. (2). L. Sevan. (3). Entire lake.

Page 100.

Cont. of Table 4.

1956	(1) М. Севан	—0,1	3,2	7,2	10,0	12,6	12,9	12,3	11,1	7,1	3,0	—0,9	—2,2	76,7
	(2) Б. Севан	0,0	3,2	6,4	9,9	12,7	13,7	13,0	11,8	7,5	4,8	0,9	—1,7	82,2
	(3) Все озеро	0,0	3,2	6,6	9,9	12,7	13,5	12,8	11,6	7,4	4,1	0,4	—1,8	80,5
1957	М. Севан (1)	—1,0	—0,9	—0,5	7,0	12,2	12,9	14,7	11,7	7,5	3,0	—0,9	—1,0	65,3
	Б. Севан (2)	—0,4	—0,9	—0,6	7,3	11,9	12,7	13,5	11,5	8,3	4,0	1,0	1,3	67,0
	Все озеро (3)	—0,6	—0,9	—0,6	7,2	12,0	12,8	13,9	11,6	8,0	3,9	0,4	—1,2	66,5
1958	М. Севан (1)	1,6	2,9	4,4	8,6	11,3	12,7	11,6	11,7	6,8	2,1	0,9	—0,4	74,2
	Б. Севан (2)	0,7	1,3	7,4	9,8	12,9	13,7	12,5	11,6	7,6	4,8	1,2	—0,9	82,6
	Все озеро (3)	1,0	1,8	6,5	9,4	12,4	13,4	12,2	11,6	7,3	4,0	1,1	—0,8	80,0
1959	М. Севан (1)	0,7	1,9	2,0	9,8	11,2	12,9	13,4	10,4	5,4	2,1	0,2	—1,3	69,0
	Б. Севан (2)	0,5	2,5	1,2	11,1	11,9	13,0	13,1	10,9	7,6	3,9	0,6	—1,1	75,2
	Все озеро (3)	0,6	2,3	1,4	10,7	11,7	13,0	13,2	10,7	6,9	3,1	0,5	—1,2	73,3
1960	М. Севан (1)	0,0	4,1	7,6	8,2	14,0	12,1	13,3	12,0	8,6	4,1	0,1	—0,9	83,2
	Б. Севан (2)	0,6	3,5	6,5	9,6	12,7	12,9	12,6	11,0	8,3	4,6	0,5	—1,0	81,7
	Все озеро (3)	0,4	3,7	6,8	9,2	13,1	12,7	12,8	11,3	8,4	4,4	0,4	—1,0	82,1
(4) Среднее многолетнее	М. Севан (1)	0,3	2,2	4,7	9,4	12,4	12,7	12,9	11,2	7,1	3,3	0,0	—0,9	75,3
	Б. Севан (2)	0,4	2,0	4,8	9,7	12,4	13,1	13,0	11,5	7,7	4,2	0,6	—1,0	78,4
	Все озеро (3)	0,4	2,1	4,8	9,6	12,4	13,0	13,0	11,4	7,3	3,9	0,4	—1,0	77,5

Key: (1). S. Sevan. (2). L. Sevan. (3). Entire lake. (4). Average many-year.

Page 101.

Table 5. Average monthly temperature of water on the surface of Lake Sevan ILLEGIBLE.

(a) Год	(b) Месяцы	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	(a) Год
1951	(1) М. Севан	—	1,4	1,9	4,3	8,6	14,2	18,5	19,2	17,8	12,[illegible]	8,2	5,9	
	(2) Б. Севан	—	1,6	2,2	5,2	9,6	13,9	17,2	19,4	17,7	12,[illegible]	8,8	6.1	
	(3) Все озеро	—	1,5	2,1	4,9	9,3	14,0	18,0	19,3	17,7	12,[illegible]	8,6	6.0	
1952	М. Севан (1)	3,2	1,9	1,6	2,8	6,0	11,8	17,5	19,4	17,8	15,[illegible]	10,3	6.0	9,5
	Б. Севан (2)	2,9	1,9	1,7	3,5	6,2	12,4	17,2	19.0	18,0	15,[illegible]	11,2	6,4	9,7
	Все озеро (3)	3,0	1,9	1,7	3,3	6,1	12,2	17,3	19,1	17,0	15,[illegible]	11,0	6,3	9,6
1953	М. Севан (1)	3,8	2,4	1,7	3,0	7,8	13,6	17,5	18,5	17,2	13,[illegible]	8,9	4.2	9,4
	Б. Севан (2)	4,1	2,3	1,7	3,4	8,1	13,5	16,6	18,0	17,1	14,[illegible]	9,4	4,4	9,4
	Все озеро (3)	1,3	2,3	1,7	3,3	8,0	13,5	16,8	18,0	17,1	14,[illegible]	9,3	4.3	9,4
1954	М. Севан (1)	1,5	(4) ледостав		1,8	4,1	12,3	18,0	19.2	17,8	[illegible]	11,6	6.5	
	Б. Севан (2)	1,2	»		2,5	6.5	12,3	17,2	18,8	17,7	14,[illegible]	11,2	7,1	
	Все озеро (3)	1,3	»		2,3	5,9	12,3	17,2	18,8	17,7	14,[illegible]	11,2	7,0	
1955	М. Севан (1)	4,6	3,5	3,3	4,5	9,8	14,5	18,3	18,7	17,0	14,[illegible]	11,0	6,0	10,5
	Б. Севан (2)	4,8	3,5	3,4	5,1	10.3	14,8	18,7	18,8	17,0	14,[illegible]	11,1	6,2	10,7
	Все озеро (3)	4,7	3,5	3,4	4,9	10,2	14,7	18,6	18,8	17,0	14,[illegible]	11,1	6,2	10,6

Key: (a). Year. (b). Months. (1). S. Sevan. (2). L. Sevan. (3). Entire lake. (4). ice formation.

Page 102.

Cont. of Table 5.

	(1) М Севан	3,9	2,5	2,0	2,9	5,2	11,8	17,0	18,2	16,4	13,0	8,5	4,7	8,8
1956	(2) Б. Севан	3,9	2,4	2,0	3,2	6,8	11,2	16,5	18,0	16,2	13,0	8,8	5,0	9,0
	(3) Все озеро	3,9	2,4	2,0	3,1	6,4	12,1	16,6	18,0	16,2	13,0	8,7	4,9	8,9
	М.Севан (1)	1,6	(4) ледостав			6,8	13,6	17,4	19,2	18,4	14,7	10,0	5,5	
1957	Б. Севан (2)	1,8	»			7,5	13,3	16,9	19,1	18,4	15,0	9,8	5,9	
	Все озеро (3)	1,7	»			7,6	13,3	17,0	19,1	18,4	14,9	9,9	5,8	
	М. Севан (1)	3,1	1,9	2,1	3,4	8,3	14,2	18,0	18,7	17,6	13,7	9,4	5,1	9,5
1958	Б. Севан (2)	3,3	1,9	2,0	3,1	8,2	14,3	17,2	18,7	17,1	13,7	9,4	5,1	9,5
	Все озеро (3)	3,2	1,9	2,0	3,2	8,2	14,3	17,4	18,7	17,2	13,8	9,5	5,2	9,6
	М. Севан (1)	3,2	1,2	ледостав (4)	1,7	6,5	13,4	17,8	18,4	16,0	12,0	9,4	6,0	—
1959	Б. Севан (2)	3,0	1,0	»	1,9	7,0	14,0	17,9	18,6	16,3	12,4	9,5	6,0	—
	Все озеро (3)	3,1	1,1	»	1,8	6,9	13,8	17,9	18,5	16,2	12,3	9,5	6,0	—
	М. Севан (1)	3,3	1,8	1,6	2,7	8,5	14,0	17,2	18,5	17,1	14,3	10,8	7,0	9,7
1960	Б. Севан (2)	3,1	1,8	1,7	3,7	9,2	14,4	17,7	18,3	17,2	14,3	11,2	7,3	10,0
	Все озеро (3)	3,2	1,8	1,7	3,4	8,9	14,3	17,6	18,4	17,2	14,3	11,0	7,2	9,9
(5) Среднее	М. Севан (1)	3,1	2,1	2,0	3,0	7,2	13,3	17,7	18,8	17,3	14,0	9,8	5,7	9,5
много-	Б. Севан (2)	3,1	2,0	2,1	3,9	8,0	13,5	17,3	18,7	17,3	14,0	10,0	5,9	9,6
летнее	Все озеро (3)	3,1	2,0	2,1	3,3	7,7	13,4	17,5	18,7	17,3	14,0	10,0	5,9	9,6

Key: (1). S. Sevan. (2). L. Sevan. (3). Entire lake. (4). ice formation. (5). Average many-year.

Page 103.

Table 6. Enthalpy of water mass of Lake Sevan at the end of the month (10^{12} kcal).

(a) Год	(b) Месяцы	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1951	(1) М. Севан			49	—	121	159	195	225	208	165	123	72
	(2) Б. Севан			113	—	279	339	439	477	456	318	259	141
	(3) Все озеро			162	—	400	498	634	702	664	483	382	213
1952	М. Севан (1)	40	32	35	57	112	149	182	196	202	164	122	90
	Б. Севан (2)	78	63	81	140	248	336	376	453	455	356	265	194
	Все озеро (3)	118	95	116	197	360	485	558	649	657	520	387	284
1953	М. Севан (1)	51	36	30	61	108	145	170	181	168	151	95	49
	Б. Севан (2)	100	59	56	141	212	269	357	423	397	345	186	88
	Все озеро (3)	151	95	86	202	320	414	527	604	565	406	281	137
1954	М. Севан (1)	(4) ледостав			34	81	139	159	—	177	125	111	95
	Б. Севан (2)	ледостав (4)			90	198	306	361	—	351	349	273	185
	Все озеро (3)				124	279	445	520	—	528	501	384	280
1955	М. Севан (1)	64	54	588	80	98	150	170	182	179	165	118	84
	Б. Севан (2)	120	100	119	180	282	344	384	427	379	357	251	154
	Все озеро (3)	184	154	177	260	380	494	554	609	558	522	369	238

Key: (a). Year. (b). Months. (1). S. Sevan. (2). L. Sevan. (3). Entire lake. (4). ice formation.

Page 104.

Cont. of Table 6.

1956	(1) М. Севан	—	—	29	55	86	137	192	199	169	—	99	53
	(2) Б. Севан	—	—	57	130	225	325	396	414	387	—	194	98
	(3) Все озеро	—	—	86	185	311	462	588	613	556	—	293	151
1957	М. Севан (1)	(4) ледостав			53	104	132	164	176	171	147	99	68
	Б. Севан (2)	—»—				231	297	385	402	414	341	217	124
	Все озеро (3)				166	335	429	549	578	585	488	316	192
1958	М. Севан (1)	44	28	31	58	105	144	158	173	176	—	111	65
	Б. Севан (2)	72	51	66	127	218	326	384	392	—	—	215	123
	Все оеро (3)	116	79	97	185	323	470	542	5 65	—	—	326	188
1959	М. Севан (1)	32	ледостав (4)		42	89	127	151	158	156	123	—	63
	Б. Севан (2)	71	—»—			227	321	355	357	378	286	—	114
	Все озеро (3)	103	—»—			316	484	506	515	534	409	—	177
1960	М. Севан (1)	36	29	30	52	101	135	166	183	167	146	116	84
	Б. Севан (2)	58	53	62	130	244	326	370	381	370	339	233	179
	Все озеро (3)	94	82	92	182	345	461	536	564	537	485	349	273

Key: (1). S. Sevan. (2). L. Sevan. (3). Entire lake. (4). ice formation.

MANY-YEAR OSCILLATIONS OF THE RUNOFF OF THE RIVERS OF BASINS KASAKH AND ARGICHI.

S. M. Musaelyan.

The study of the many-year oscillations of runoff has high scientific and practical value for the solution of many important problems of water power, water management and planning of agricultural production in the regions of the irrigated agriculture. However, to this question little attention is comparatively given. The laws governing the many-year oscillations, in particular, occurrence of cycles and asynchronism of runoff under the mountain conditions, where the clearly expressed vertical zonation of shaping of runoff occurs, are especially insufficiently studied.

Maintaining of the secular supplies of water of Lake Sevan, rational planning and use of water resources in the Armenian SSR, known, has extremely high value. Special position in the complex use of waters of Lake Sevan and Araratskoy valleys occupies river Kasakh, whose runoff for the purpose of irrigation will be regulated by Aparanskim reservoir in the near future. River Argichi is water-bearing in the basin of Lake Sevan. Its liquid-water content is approximately 30% of entire surface inflow into Lake Sevan.

In connection with this, the study of laws governing the

many-year oscillations of runoff in the basins of the rivers indicated is of specific scientific and practical interest. Basic data on the rivers examined and alignments are cited in Table 1.

Page 106.

By cycle and occurrence of cycles in this article is implied the respectively completed group of shallow or water-abundant years and change or the alternation of these groups. However, by asynchronism is implied the noncoincidence of liquid-water content in the separate years (intra-cyclic asynchronism) and the cycles (cyclic asynchronism).

Cyclic asynchronism is evaluated by the coefficient of cyclic asynchronism (η), represented by itself the relation of average liquid-water content in the cycle of the compared rivers, i.e.

$$\eta = \frac{k_{\text{э}}}{k_c}$$

where $k_{\text{э}}$ - average modular coefficient of runoff in the cycle of river-standard,

k_c - average modular coefficient of runoff in the same cycle of the compared river.

Table 1. List of the rivers examined and alignments.

(a) Река-пункт	(b) Средняя высота бассейна, м.	(c) Площадь водосбора, кв. км	(d) Период наблюдений	(e) Использованный ряд наблюдений	(f) Средний многолетний расход в кбм/сек, за:		
					(g) год	(h) половодье	(i) межень
(1) Бассейн р. Касах							
(2) Касах—с. Апаран	2320	385	1928–62	1928—62	0,44	2,44	0,21
(3) Касах—г. Аштарак	2150	1020	1925—62	1928—62	6,80	14,6	3,30
(4) Гехарот—с. Арагац	3100	39,5	1933—62	1933—62	0,84	2,11	0,27
(5) Бассейн р. Аргичи							
(6) Аргичи—с. Геташен	2470	366	1927—62	1946—62	4,93	13,2	2,02
(7) Карадзи—с. Карадзи	2600	22,0	1946—62	1946—62	1,57	3,52	0,92
(8) Чингиля—с. Яных	2820	13,6	1946—62	1946—62	0,22	0,42	0,13

Key: (a). River-point. (b). Medium altitude of basin, m. (c). Area of drainage basin, square kilometer. (d). Period of observations. (e). The series of observations used. (f). Average multi-year expenditure in kbm/sec, for: (g). year. (h). flood. (i). low-water level. (1). Basin of river Kasakh. (2). Kasakh - state of Aparan. (3). Kasakh - city of Ashtarak. (4). Gekharot - state of Aragats. (5). Basin or river Argichi. (6). Argichi - state of Getashen. (7). Karadzi - state of Karadzi. (8). Chingil - state of Yanykh.

Page 107.

This method, in contrast to the method of the comparison of the security of runoff in cycle [4], can be used also with the numbers with the different duration, if the norm of the latter is not changed (or is changed insignificantly) with an increase in the number of terms of series.

Intra-cyclic asynchronism is evaluated by the correlation coefficient between the runoff of the compared rivers.

Flood and low-water runoff is examined annually. The isolation of runoff for the flood and the low-water level is produced on the hydrographs in all years of observations. To complete account for the hydrological special features of the water conditions of the rivers examined the boundaries of these seasons were established, on the basis of the special features of each specific year.

The normalized (according to C_v) difference integral curves of the modular coefficients of annual, flood and low-water runoff are given in Fig. 1-3. As can be seen from Fig. 1, in the course of annual runoff of river Kasakh in the city of Ashtarak it is possible to isolate two characteristic cycles:
1928-1939 - shallow, probably incomplete, 1940-60 yr. - water-abundant.

Shallow cycle 1928-39 yr. is interrupted not by one year of opposite sign. Cycle 1940-60 yr., being as a whole water-abundant, in the middle part (1945-51 yr.) has a liquid-water content close to the average, in some years (1956, 58 yr.) it is interrupted by the liquid-water content of opposite sign.

The course of the oscillations of liquid-water content of river

Kasakh in the state of Aparan differs from the course of runoff in the city of Ashtarak. Thus, the shallow cycle, which in Ashtaraka encompassed 1928-39 yr., here ends in 1934, and the water-abundant cycle, which is continued only to 1946, further begins. Another shallow cycle (up to 1962) begins in 1947, whereas during this period in city of Ashtarak is observed the abundance of water.

The occurrence of cycles of the annual runoff of river of Gekharot also does not coincide with the course of runoff of river Kasakh in the city of Ashtarak.

Page 108.

It is possible to isolate on river of Gekharot: 1933-42 yr. - water-abundant, 1943-47 yr. - shallow cycle. The alternation of 2-3 summer groupings of abundance of water and lack of water further occurs.

Thus, it is possible to conclude that the occurrence of cycles of annual runoff of river Kasakh is characterized by instability both on the high-altitude zones of river itself and according to inflows.

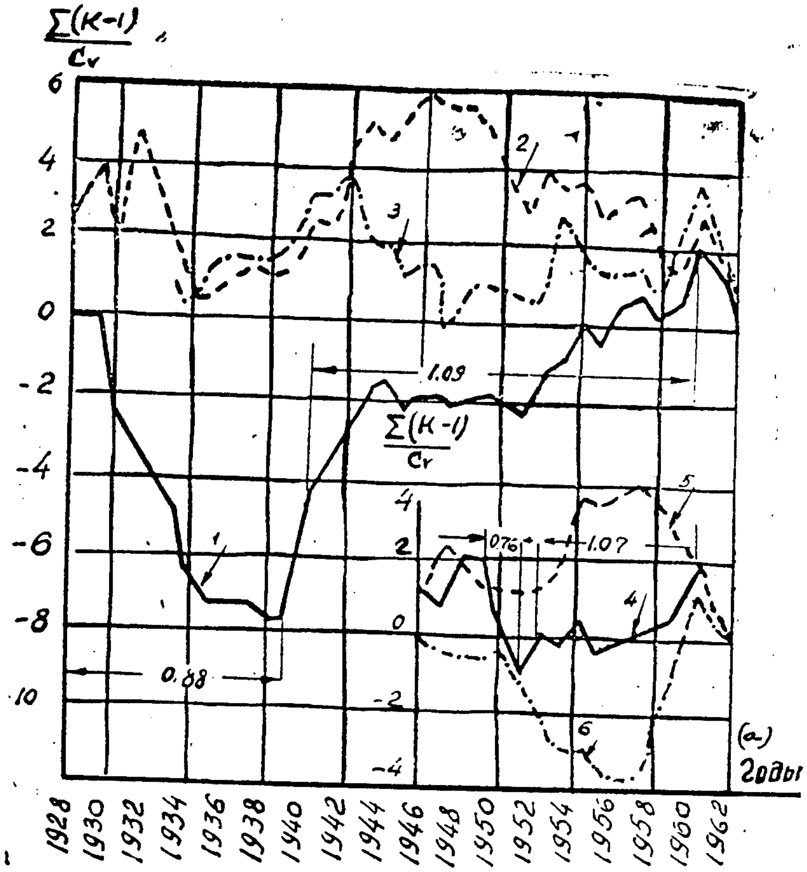

Fig. 1. Normalized difference of integral curves of modular coefficients of annual runoff. 1 - state Kasakh - state of Ashtarak; 2 - river Kasakh - state of Aparan; 3 - river of Gekharot - state of Aragats; 4 - river of Argichi - state of Getashen; 5 - river of Karadzi - state of Karadzi; 6 - river of Chingil - state of Yanykh. Key: (a). Years.

Page 109.

The noncoincidence of cycles according to the boundaries and duration, and for the separate cycles and opposite course of liquid-water content cause by itself the presence, besides cyclic, also the

considerable intra-cyclic asynchronism of annual runoff (Table 2, 3). If we accept conditionally asynchronous such cycles, during which the value η differs from one by ±10% and more, then, as are shown the data of Table 2, cycles of river Kasakh on compared alignments and the rivers are asynchronous. It should be noted that during the determination of cyclic asynchronism from the cycles of river of Gekharot, value η are much more than those given in Table 2. As can be seen from table 3, with an increase in altitude of basin the degree of asynchronism of annual runoff of river Kasakh also increases.

From Fig. 1 it is evident that in the oscillations of the annual runoff of river of Argichi in the state of Getashen are separated:

1949-51 yr. - shallow cycle, 1952-60 yr. - water-abundant. In river of Karadzi [1] the direction of runoff in 1949-51 yr. coincides with the direction of the curve of the runoff of river of Argichi, and water-abundant cycle of 1952-60 yr. ceases here in 1957, further in 1960 the course of liquid-water content is opposite to the course of the liquid-water content of river of Argichi.

FOOTNOTE [1]. River Argichi in the headwaters is called river of Karadzi. ENDFOOTNOTE.

In river of Chingil the lack of water is observed in 1946-57 yr., and water-abundant cycle begins only in 1958. Thus, it is possible to note that also under the conditions of river of Argichi the occurrence of cycles of annual runoff undergoes large changes.

Cyclic asynchronism, as can be seen from Table 2, is observed only during the period of 1949-51 yr. However, during the comparison on the cycles of the rivers of Karadzi and Chingil, the deviation of values η from them can reach to ±0.30-0.40.

Data of Table 3 show that with an increase in the height of basin the annual degree of asynchronism runoff under the conditions of river Kasakh, increases.

Occurrence of cycles of flood runoff of river Kasakh in city of Ashtarak is the following (Fig. 2): 1930-39 yr. - shallow cycle, 1940-56 yr. - water-abundant.

Page 110.

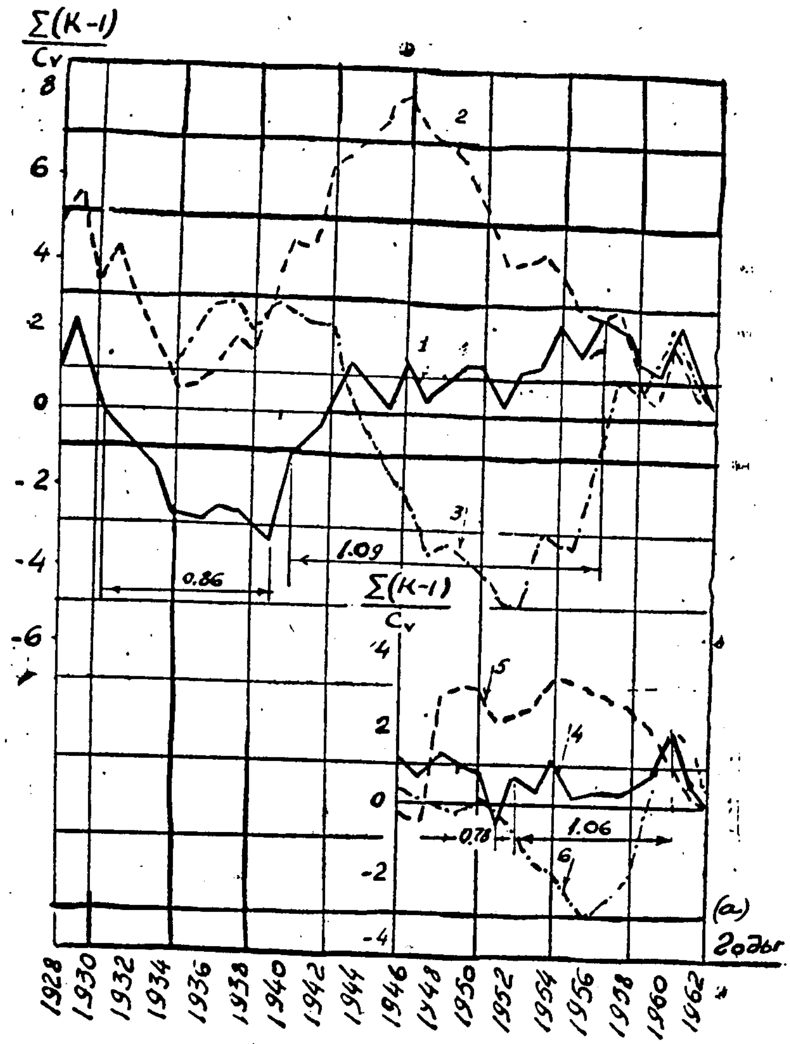

Fig. 2. Normalized difference integral curves of modular coefficients of flood runoff. 1 - river Kasakh - state of Ashtarak; 2 - river Kasakh - state of Aparan; 3 - river of Gekharot - state of Aragats; 4 - river of Argichi - state of Getashen; 5 - river of Karadzi - state of Karadzi; 6 - river of Chingil - state of Yanykh.

Key: (a). Years.

Page 111.

Kasakh in the state of Aparan the oscillations of the runoff of flood are peculiar in the river. Thus, are separated: 1930-34 yr. - shallow cycle, 1935-46 yr. - water-abundant, 1947-62 yr. - shallow. On Gekharot river also are separated the independent cycles: 1938-52 yr. - shallow, 1953-60 yr. - water-abundant.

Thus, the occurrence of cycles annual flood runoff of river Kasakh, is characterized by instability on the height and inflows. Cycles do not coincide both in the boundaries and the duration and in certain cases according to the sign of liquid-water content. Cyclic and intra-cyclic asynchronism, as show data of Table 2 and 3, with an increase in the height of basin increases.

Fig. 2 shows that the occurrence of cycles of the runoff of the flood of river of Argichi is also very unstable according to the height of basin. Here also, as in annual runoff, during some periods occurs opposite direction of runoff curve. This visually becomes apparent in 1954-60 yr., when on two adjacent rivers of Karadzi and Chingil occurs the opposite course of liquid-water content. An increase in the cyclic and intra-cyclic asynchronism on the height of drainage of basin is confirmed by data of Table 2 and 3.

The low-water runoff of river Kasakh in city of Ashtarak is detected in following cycles (Fig. 3): 1928-37 yr. - shallow, 1938-60 yr. - water-abundant.

These cycles are barely interrupted by years with the liquid-water content of opposite sign. The occurrence of cycles of the runoff of low-water level in the state of Aparan is almost the same, if we do not consider that here the years with the liquid-water content of opposite sign are encountered more frequently, and also occurs the noncoincidence of beginning and end of the cycles for 1-2 years.

On Gekharot river the cycles indicated are also expressed sufficiently clearly. At the same time here occurs the noncoincidence of the boundaries of cycles and sign of liquid-water content in 1954-58 yr.

Cyclic and intra-cyclic asynchronism of low-water runoff of river Kasakh is less in comparison with the annual and flood runoff, which is evident from tables 2 and 3. This is explained by the large underground control of runoff.

Page 112.

The analysis of the integral curve of the runoff rivers of Argichi and Chingil (Fig. 3) shows a comparatively large stability of the occurrence of cycles of low-water runoff in comparison with the annual and flood runoff. Here the oscillations of the runoff of river of Argichi equate, in essence, to the oscillations of the runoff river of Chingil. At the same time they differ significantly from the oscillations of the runoff of river of Karadzi. On the latter runoff curve in 1954-60 yr. has opposite direction with respect to the curves rivers of Argichi and Chingil.

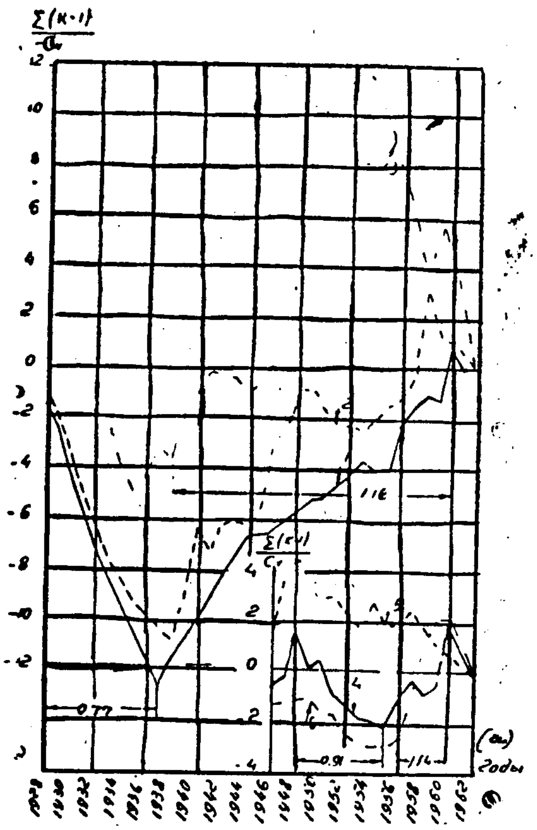

Fig. 3. Normalized difference integral curves of modular coefficients of low-water runoff. 1 - river Kasakh - city of Ashtarak; 2 - river Kasakh - state of Anaran; 3 - river of Gekharot - state of Aragats; 4 - river of Argichi - state of Getashen; 5 - river of Karadzi - state of Karadzi; 6 - river of Chingil - state of Yanykh.

Key: (a). Years.

Page 113.

Table 2. Values of the coefficients of cyclic asynchronism (η).

(a) Циклы	(b) Голового стока		(c) Половодного стока		(d) Меженнего стока	
	(1) а) по циклам р. Касах у г. Аштарак					
(2) Река-пункт	1928—39	1940—60	1930—39	1940—56	1928—37	1938—60
(3) Касах-Апаран	1,18	0,84	1,13	0,88	0,89	1,03
(4) Гехарот-Арагац	—	0,80	—	0,84	—	0,95
	(5) б) по циклам р. Аргичи у с. Геташен					
	1949—51	1952—60	1949—51	1952—60	1949—55	1956—60
(6) Карадзи-Карадзи	1,20	0,94	1,17	0,92	0,99	0,84
(7) Чингил—Яных	1,19	0,98	1,18	1,04	1,04	1,12

Key: (a). Cycles. (b). Annual runoff. (c). flood runoff. (d). low-water runoff. (1). a) cycles of river Kasakh in city of Ashtarak. (2). River-point. (3). Kasakh-Aparan. (4). Gekharot-Aragats. (5). b) cycles of river of Argichi in state of Getashen. (6). Karadzi-Karadzi. (7). Chingil-yanykh.

Table 3. Values of the coefficients of correlation between the runoff (numerator) and the standard errors of their calculation (denominator).

(a) Река-пункт	(b) Годовой сток		(e) Половодный сток		(f) Меженний сток	
	(c) Касах-Апаран	(d) Гехарот-Арагац	(c) Касах-Апаран	(d) Гехарот-Арагац	(c) Касах-Апаран	(d) Гехарот-Арагац
(1) Касах—Аштарак	$\frac{0,50}{0,13}$	$\frac{0,40}{0,16}$	$\frac{0,50}{0,13}$	$\frac{0,38}{0,14}$	$\frac{0,68}{0,10}$	$\frac{0,36}{0,16}$
	(2) Карадзи-Карадзи	(3) Чингил-Яных	(2) Карадзи-Карадзи	(3) Чингил-Яных	(2) Карадзи-Карадзи	(3) Чингил-Яных
(4) Аргичи-Геташен	$\frac{0,60}{0,16}$	$\frac{0,45}{0,20}$	$\frac{0,50}{0,19}$	$\frac{0,40}{0,21}$	$\frac{0,25}{0,23}$	$\frac{0,20}{0,24}$

Key: (a). River-point. (b). Annual runoff. (c). Kasakh-Aparan. (d). Gekharot-Aragats. (e). flood runoff. (f). low-water runoff. (1). Kasakh-Ashtarak. (2). Karadzi-Karadzi. (3). Chingil-yanykh. (4). Argichi-Cetashen.

Page 114.

The greatest asynchronism, as can be seen from table 3, differs for the low-water runoff (besides the combinations of rivers of Kasakh-Ashtarak and Aparan), least- annual. In certain cases, as show the standard errors of the coefficient of correlation σ, is calculated according to the formula:

$$\sigma = \pm \frac{1-r^2}{\sqrt{n}}$$

where: r - the coefficient of correlation, n - the number of paired members of number, value of the correlation coefficient are nearly equal (or even less) to its error, i.e., it is possible to consider them as random. In a number of cases in the absence or a

comparatively small value of cyclic asynchronism a noticeable intra-cyclic asynchronism can be observed and, on the contrary, in the absence of the latter the first can have high value. It should be noted that on all rivers examined and alignments of the oscillation of annual runoff almost completely are equated to the oscillations of flood runoff.

Speaking about the reasons for occurrence of cycles, cyclic and intra-cyclic asynchronism of runoff under the mountain conditions, it is necessary to keep in mind that the study of these phenomena has only started. In connection with this, to examine entire complex contributing factors with their detailed analysis is at present impossible. Let us note only qualitatively that among the remaining factors the varied conditions for precipitation and consumption of atmospheric precipitations play the greatest role. Under certain conditions the occurrence of cycles of precipitation and temperatures, being inseparably connected with the occurrence of cycles atmosphere circulation, under the effect of the local factors can be essentially different in the limits even of small basins. Complex mountain relief contributes to the formation of its own climate in the separate basins or the parts of basin.

Page 115.

In this respect the significantly Sevan plateau, where under the effect of the warm foehn winds blowing from the mountains, the annual amount of precipitation on the mark 1900 m and higher rarely exceed

335 mm, whereas in the adjacent basins at the appropriate heights of precipitation it can be two times more. High value has also the exposure of slope. Thus, on the northern slope of the Vardenisskyy ridge in the basin of river of Chingil, at the height of 2335 m falls for the course of the entire year 448 mm, and on the southern slope at the height 2080 m - 764 mm [2]. In connection with this the many-year oscillations of liquid-water content in the limits even of small regions can be very diverse.

CONCLUSIONS.

1. In the many-year oscillations of annual, flood and low-water runoff of rivers Kasakh and Argichi is observed the sufficiently clearly expressed occurrence of cycles, which in connection with the complex mountain relief, the varied conditions for precipitation and consumption of precipitation becomes apparent differently both on the separate alignments of one and the same river and inflows.

Differences in the cycles of lack of water or abundance of water become apparent in the time of their onset and duration, and sometimes and in the sign of liquid-water content.

The stability of the occurrence of cycles of the low-water runoff is more than the annual flood runoff. The occurrence of cycles of annual runoff is similar to the occurrence of cycles of flood runoff, whereas in the low-water runoff are detected differences in the time

of onset and duration of cycles.

2. For the quantitative expression of cyclic asynchronism is introduced the coefficient of cyclic asynchronism, which is the relation of liquid-water contents (average modular coefficients) in the cycle along the river - standard and compared river. It turned out that on the conditional limit of asynchronism accepted on the rivers in a number of cases examined, observed are asynchronous cycles.

Cyclic asynchronism increases with an increase in the height. In this case the asynchronism of the annual and flood runoff increases more than low-water runoff.

Page 116.

3. Intra-cyclic asynchronism is evaluated on the correlation coefficient. Intra-cyclic asynchronism increases with an increase in the height of basin. In this case the low-water runoff of such an increase is greater than in annual and flood runoff.

4. In connection with the diversity of formation conditions for runoff under the mountain conditions the obtained outputs should not be spread to other rivers of Armenian SSR.

REFERENCES.

1. **Андреянов В. Г.**—Циклические колебания годового стока и их учет при гидрологических расчетах. Труды ГГИ, вып. 68, 1959.

2. **Нерсесян А. Г.**—Климат Армении (на армянском языке). Айпетраг, Ереван, 1964.

3. **Сомов Н. В.**—Асинхронность и цикличность колебаний стока крупных рек СССР. Труды ЦИП, вып. 117, 1963.

4. **Хамьянова Н. В.**—Асинхронность стока крупных рек Средней Азии. Изд. АН Кирг. ССР, Фрунзе, 1961.

Page 117.

SOME SPECIAL FEATURES OF THE WINTER CONDITIONS OF THE TEMPERATURE OF SHELTERING VITICULTURE.

R. S. Mkrtchyan, A. M. Kirakosyan, Z. V. Sadoyan, L. S. Khachatryan.

The basic region of viticulture in Armenian SSR is the Araratskaya plain, where the winter is very variable. In some years the temperature of air reaches up to -27, -31°, while into others it does not descend below -10 -15°. Viticulture here is especially sheltered. Wintering sheltered grape bushes passes to the peculiar microclimatic conditions, judging by the readings of instruments on the instrument platform is impossible. Differences become especially noticeable under the conditions of the so-called pedestal system of the cultivation of grapes, when bush is located on the earth rises by height from 0.5 to 1.0 m, with width from 0.8 to 1.2 m.

Truth, currently the present pedestal system of landing vineyards is almost none; it is substituted with the espalier system, where the rises earth has somewhat smaller sizes, however, on the basis of the special features of the irrigated viticulture, even in the espalier system are small earth rise ("stones"). After the shelter of bushes the height of these rises approximately 1.5-2.0 times increases, since entire rod is bent down to the vertex of rise, and then is concealed by the earth with a thickness of 15-20 cm.

Page 118.

In this case the earth usually is taken from the aisles, with the overall sizes of rise even more greatly increase. Thus, on the vineyards is created peculiar microrelief and connected with it microclimatic conditions. Microclimatic special features are very noticeable in the direction of numbers from the west to the east, since the southern slant of rise is warmed thoroughly by the sun considerably stronger than northern slant.

For studying the winter and early-spring temperature conditions of sheltered rod the forces of Erevan agro-meteorological station UGMS [Administration of the Hydrometeorological Service] of Armenian SSR and scientific research institute of viticulture, wine making and fruit-growing (NII [Scientific Research Institute] VViP) on the Parakarskoy basis of NII VViP selected the pilot area of the most common type of grapes "Voskeat" of decennial age. The direction of rows was from the northeast to southwest. This direction sufficiently successfully reflects the average temperature conditions of the rows, directed both from the north to the south, and from the east to the west.

It is necessary to assume that in the direction of rows from the north to the south the contrasts of temperatures between different slants of rise will be considerably less than in their direction from the east to the west.

The microclimate of sheltered vineyards is caused by different heating of the slants of earth rise by direct sun rays and by alternation of earth rises with concave interrows. These factors create both the radiation differences and condition for the stagnation of cold air in interrows. Therefore with the clear sky their temperature in the daytime strongly differ between themselves the solar and shadow slants of rise, and at night - convex rise and concave interrows.

The height of earth rise in the pilot area was 0.5-0.8 m, its width in the middle part of 1-1.2 m. Terrain had weak gradient not more than 2-3° to the southeast.

Page 119.

In the section were established soil-exhaust thermometers at depths 20, 40, 60, 80 cm on the rise between the grapevines; minimum and maximum thermometers is established on the southeastern, northwestern slants and at the vertex of rise. Its height and density was measured in the days with snow cover.

Observations were conducted in winters 1960-61, 1961-62, 1962-63 daily in 8.12 and 20 hours of local time.

The winter of 1961-62 was relative to warm, without snow. The winter of 1961-62 was also warm; however, in the first ten-day period

of January suddenly it cooled and minimum temperature of air was lowered to - by 23.5°, and soil - 28°. The second temperature drop in the third ten-day period of January was considerably more weakly - minimum temperature of air was lowered to - 16.8°, and surface of soil - 20°. The winter of 1962-63 was also warm. All three winters were unstable, which is characteristic for the Araratskoy valley.

Results of investigations.

During the comparison of the temperature of different slants and vertex of the rise between themselves, and also with the temperature in the weather instrument shelter was explained a number of laws.

Minimum temperatures at night with the moderate frost (from -10 to -18°) on the surface of the southeastern and northwestern slants of rise are lower than at the vertex, and with weak frost (0-10°), on the contrary, vertex is colder than slants.

This is caused by the fact that on the moderate-frost nights was observed clear windless or with light breeze weather, as a result of which arose surface temperature inversion. This into its place led to the fact that the interrow depression was filled with cold air.

Page 120.

The peculiar alternation of air cold furrows and comparatively warm rises is created on such nights on the sheltered vineyards.

On the weakly-frost nights there was the windy weather. This led to the fact that the vertexes of rises proved to be colder than the those shielded from the wind troughs. During such days the picture distributed the temperature in the field with the sheltered grape bushes reverse, i.e., warm troughs are alternated with the cold vertexes of rises. However, uniform temperature is observed during the cloud days.

It is difficult to derive precise quantitative indices of the dependence of minimum temperatures of the different parts of the grape rise, since this is connected with many variable factors (sizes and direction of rise, soil moisture, weather conditions, etc.), whose account is almost impossible. However, in the first approximation, it is possible to say that on the clear light-winded nights with moderate frost (from -10 to -18°) on the slants of rises minimum temperature on 1-2° is lower than at their vertexes, and on the windy or cloudy weakly-frost nights (from 0 to -10°), on the contrary, slants on 1-2° warmer than the vertex or their temperature is equal. It is explained that minimum temperature of both slants is almost identical in the moderately frost nights, and in the night with the weak frost SE slant of rise is approximately 1-1.5° warmer than NW.

Maximum temperatures. For the sheltered grapevine the high value is not only the night minimum, but also daytime maximum temperatures and their alternation in the time. Observations showed that the

higher the temperature, the greater the difference between maximum temperatures NW and SE slants of rise.

After entering on daily graph the maximum temperatures on NW and SE slants of rise the correlation dependence, whose results were shown in Table 1, were obtained.

Page 121.

Data of Table 1 illustrate well the increase of difference in maximum temperatures of slants in proportion to an increase in the general background of temperature.

Thus, during the almost identical conditions of nighttime temperatures as in the daytime the SE slant can be warmed thoroughly to 1-17° more than NW. It is clear that during the arrangement of rows from the west to east these differences will still be greater.

The analysis of daily variation of the soil surface temperature on SE and NW slants of rise during February and March 1961 showed that the daily amplitude of temperature on NW slant composes approximately 18°, and on SE --33°. In this case in separate sunny days the temperature on SE slant reached 42°, and at night, fell to -6°; Thus, daily amplitude composed 48°, whereas on NW slant with maximum amplitude (28°) in the daytime temperature reached 9°, and it at night fell to - 19°.

In order to have more concrete representation about the daily amplitude of temperature on different slants are brought data of separate days (Table 2).

Table 1. Ratio of maximum soil surface temperatures on SE and NW slants of grape rise in the winter-spring period of 1961-63 yr.

(a) На ЮВ откосе			(f) На СЗ откосе		
(b) средняя (по кривой)	(c) пределы колебания		(b) средняя (по кривой)	пределы колебания (c)	
	(d) от	(e) до		от (d)	до (e)
0	—1	10	—1	—2	1
5	2	13	2	—1	5
10	5	20	5	—1	10
15	8	28	8	3	14
20	12	36	11	5	19
25	15	38	14	7	22
30	19	40	17	9	27
35	22	40	20	11	30
40	26	40	23	13	30

Key: (a). On SE slant. (b). average (on the curve). (c). the limits of oscillation. (d). from. (e). to. (f). On NW slant.

Page 122.

Thus, in the most favorable days for the radiation heating and the coolings of soil a difference in the minimum temperatures on the differently oriented slants of grape rise to the limits from -0.7 to 3.0° (on the average of 0.9°); meanwhile a difference in maximum temperatures in these days oscillated from 12.8 to 26.8° (on the average of 19.5°).

From the same table it is evident that SE slant in the daytime is intensely warmed thoroughly, and at night it is intensely cooled, whereas NW slant is weakly warmed thoroughly and comparatively is cooled little.

Table 2. Maximum and minimum soil surface temperatures on SE and NW slants of grape rise on the clear days.

(a) Дата	(b) Минимальная температура			(d) Максимальная температура		
	ЮВ	СЗ	(c) разность	ЮВ	СЗ	разность (c)
15.II-61	—3,0	—4,3	1,3	25,4	12,6	12,8
16.II	—5,8	—5,9	0,1	28,0	13,6	14,4
17.II	—6,2	—6,7	0,5	30,7	11,0	19,7
18.II	—4,7	—5,4	0,7	33,1	12,6	20,5
19.II	—9,5	—10,4	0,9	35,2	12,7	22,5
20.II	—9,2	—12,2	3,0	34,0	10,1	23,9
21.II	—9,0	—11,2	2,2	35,0	13,5	21,5
22.II	—7,4	—10,0	2,6	32,3	17,2	15,1
23.II	—7,5	— 9,3	1,8	36,6	17,0	19,6
24.II	—6,6	— 8,0	1,4	36,2	18,2	18,0
25.II	—8,4	—10,0	1,6	37,7	18,7	19,0
9.III	—4,7	—4,0	—0,7	21,9	8,0	13,9
10.III	—6,2	—6,3	0,1	31,2	12,0	19,2
11.III	—7,5	—7,6	0,1	35,0	13,5	21,5
12.III	—6,6	—6,0	—0,6	37,5	13,4	24,1
13.III	—5,6	—5,6	0,0	42,0	15,2	26,8
(1) Средн.	—6,8	—7,7	0,9	33,2	13,7	19,5

Key: (a). Date. (b). Minimum temperature. (c). difference. (d). Maximum temperature. (1). Average.

Page 123.

Because of this the nighttime temperatures on these slants are distinguished insignificantly. This speaks even, that with early spring the daytime warming up of soil has small inertia, little penetrates deep layers of soil, since almost entire heat at night is radiated from the surface of soil and only insignificant part is detained in its upper layers.

From the aforesaid it is possible to draw one important

conclusion about the fact that NW slant has more favorable temperature conditions for the wintering of grape bush, than SE, since slant daily variations of temperature are approximately 15-20° less on NW.

The advantages of NW slant are especially manifested by the early spring, when after the melting of snow cover the bare soil begins rapidly to be warmed thoroughly and the nodules of grape bush can swell under the shelter. Opening of vineyards is inexpedient during this period, since the probability of the return of dangerous frost is still large. Therefore for preventing bloating the nodules under the shelter and damaging the vineyards from the return of late cold returns expediently with the shelter of vineyards of above-ground part of the bush to bend to the northern slant of the rise, where the force of frost as the NW slant, but snow descends on SE slant and soil is warmed thoroughly for approximately 5-7 days more than earlier. Winter thaws here are manifested more weakly and do not present danger for weakening of frost resistance and early awakening of the nodules of grapevine under the soil.

The revealed above dependences of the temperature of distinctive slants of grape rise can be used the operational agrometeorological servicing of grapevines in particular for the analysis of passed conditions of wintering and forecast of winter-spring state of vineyards and in further for the giving of recommendation about expedient period of the opening vineyards.

Page 124.

At present for this used is data of the meteorological stations, which are not able to a sufficient degree to characterize the microclimatic conditions of vineyards.

Utilizing data of microclimatic observations on the vineyards, we placed before ourselves also the problem of establishing connection between temperatures of grape rises and air in the weather instrument shelter in order, in the absence of direct observations in vineyards, to have a representation about their temperature conditions according to the data of the nearest meteorological stations.

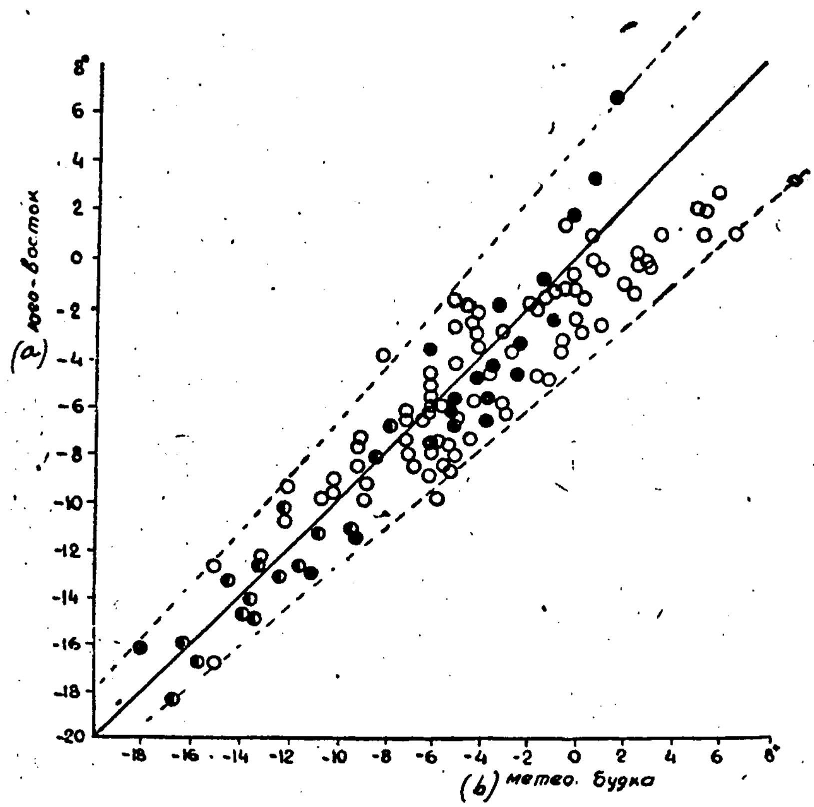

Fig. 1. graph of connection of minimum temperatures, measured on the surface of grape rise (southeastern slant) and air in the weather instrument shelter.

Key: (a). southeast. (b). meteorological booth.

Page 125.

As can be seen from the graph of connection between temperatures of air and surface of the soil of SE slant of rise (Fig. 1), the night minimums are nearly equal. They usually consider that minimum temperature on the surface of soil, on the average is 2° lower than air at the height of 2 m (in the weather instrument shelter). However, with respect to SE slant this is not confirmed. Here

insignificant differences with the temperature of air in the booth are noted only during small frost and positive nighttime temperatures. But if we speak about NW slant, the minimum temperatures are already clearly lower than in the weather instrument shelter (see Table 3). In this case the warmer the night the difference in temperatures is greater.

Table 3. Ratio of minimum temperatures in the weather instrument shelter and on the surface of soil on NW slant of grape rise.

(a) В будке	(b) На СЗ откосе		
	(c) в среднем	(d) Пределы колебаний	
		(e) от	(f) до
6	3	—3	8
4	1	—4	6
2	0	—6	4
0	—2	—7	2
—2	—4	—8	0
—4	—6	—10	—2
—6	—7	—11	—4
—8	—9	—13	—6
—10	—11	—14	—8
—12	—12	—16	—10
—14	—14	—17	12
—16	—16	—19	—14
—18	—17	—20	—15

Key: (a). In the booth. (b). On NW slant. (c). on the average. (d). Limits of oscillations. (e). from. (f). to.

Page 126.

Of three basic elements of the relief of grape rise (SE, NW slants and vertex) the most essential differences in the temperature, in comparison with the temperature of the weather of instrument shelter, has the vertex (see Fig. 2).

Fundamental distinction of connection between nighttime temperatures of the vertex of rise and air in the weather instrument shelter consists in the fact that sharply does not increase at a comparatively high temperature of their difference, as this is observed on the slants.

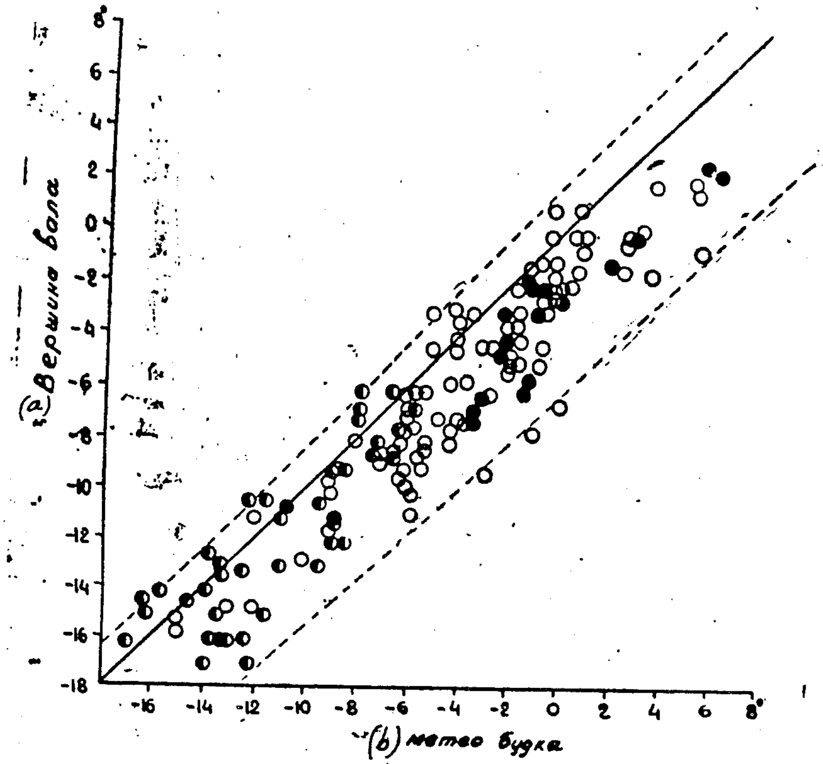

Fig. 2. - the graph of connection of minimum temperatures of soil at the vertex of grape rise and air in the weather instrument shelter. Key: (a). vertex of rise. (b). Meteorological booth.

Page 127.

This can be explained by the fact that the vertex is the small horizontal surface, which is raised above the slants of rise, and with considerable frost it remains out of the effect of inversion. This leads to the fact that the vertex in the night time behaves as even surface, where minimum temperature on 1-3° is lower than in the weather instrument shelter.

The approximate determination of minimum temperature on the

surface of grape rise from the temperature of air is possible to produce with the aid of table 3 and graphs (Fig. 1 and 2). Let us point out for an example that if the minimum of the temperature in the booth was -10°, then on SE slant it will also be -10°, on NW slant -11°, and vertex -12°. As can be seen from table, average values have considerable oscillations, in connection with which it is possible to consider them only as approximates.

Connection between maximum temperatures NW slant of rise and air in the weather instrument shelter is shown in Fig. 3. Nature of connection between temperatures SE slant and booth is the same, although in this case the differences in the temperature are more.

In both cases the maximum temperature in the weather instrument shelter is substantially lower than on the slants of rise; approximately to 3-8° in comparison with NW slant, to 4-16° in comparison with SE.

It is clear that in the presence of this large oscillation in the average values it is difficult to determine the value of maximum temperature on SE or NW slants of grape rise according to the maximum temperature of air.

The weak correlation between maximum temperatures of air and surface of soil is generally sufficient clear, especially with the changing soil moisture. Observations showed that the maximum

temperature of air on the instrument platform weakly is correlated with the maximum temperature of the underlying surface even on the same area.

Page 128.

For studying the winter-spring thermal mode of sheltered grapevine in the rise at depth 20, 40, 60 and 80 cm were installed soil-exhaust thermometers. In the sheltered form the base mass of the grapevine is located at the depth of approximately 10-25 cm.

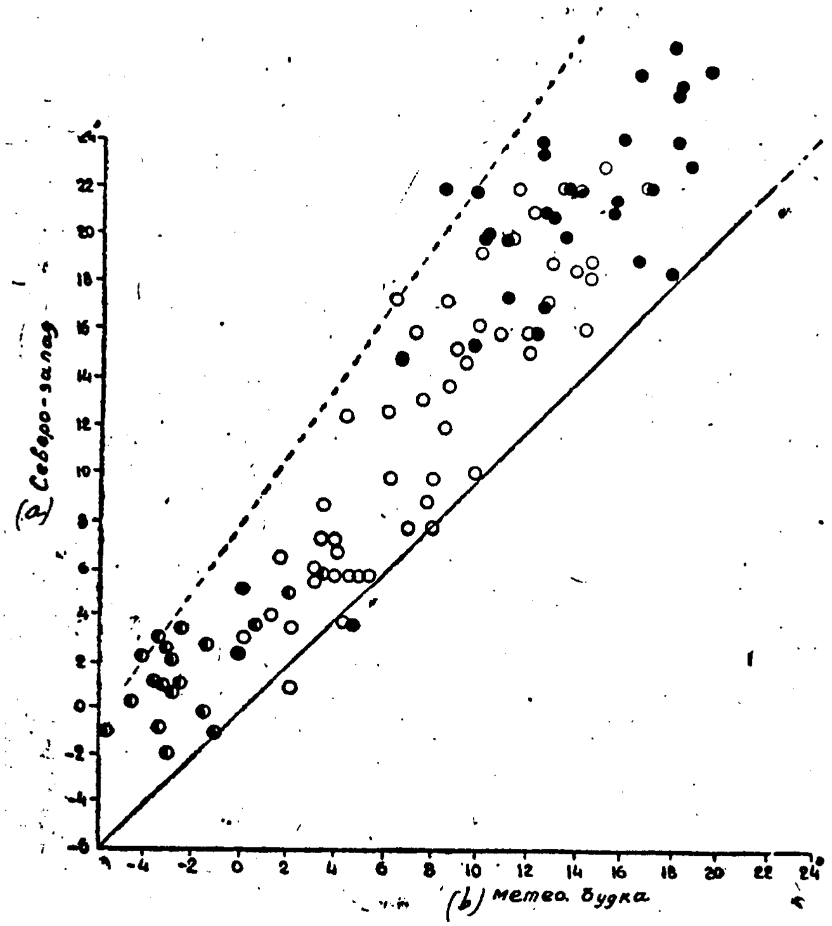

Fig. 3. - the graph of maximum temperatures of soil on NW slant of grape rise and air in the weather instrument shelter.
Key: (a). Northwest. (b). Meteorological. booth.

Page 129.

Consequently the winter-spring temperature conditions of vineyards better can be judged from the thermometer, installed on depth of 20 cm.

As it was indicated above, winter-spring periods even 1962 were relatively warm and dry. Low temperature at the depth of 20 cm did

not drop to -3° in the grape rise and -1° in the soil on meterological site. If one considers that into separate cold year at the depth of 20 cm were observed frost on the order of 3-4°, then it is possible to assume that within the rise can be observed frost of 5-7°.

Daily observations showed that temperature of grape rise at the depths from 20 to 80 cm on 1-5°, at the appropriate depths in the soil upon horizontal surface (on the instrument platform). This is explained by the fact that the rise, of convex form of relief is stronger; heated, in essence, from one side and heat is spread in two directions - lower cold (shadow) side of rise. Meanwhile horizontal surface is cooled relatively weaker, and warming heat spreads, in essence, downward.

The shadow side of the grape rise not only does not ILLEGIBLE to itself direct solar rays, but also more moisture consequently possesses larger heat capacity and during arrival of heat to this side it mainly ILLEGIBLE for the evaporation. If in the day time shadow of rise receives the very weak part in the heating ILLEGIBLE of rise, then in the night time this side on the level with southern side participates in the process of heat radiation from the soil. In such a case, the cold (humid) side is the considerably lower temperature background of grape rise.

Fig. 4 gives data according to the temperature ILLEGIBLE (depth of 20 cm) on the instrument platform and in vineyard rise.

Page 130.

From the figure one can see that in the spring of 1961 in proportion to the heating of soil the difference between its temperatures on the instrument platform and in the grape rise increases from 1.0-1.5° to 4-5°, in 1962 these differences remain almost unchanged in limits of 1.5-2.0°. This is explained by the fact that the spring 1961 was more humid than in 1962. Because of this in 1961 the northwestern side of rise for a long time remained humid and the significant part of the entered heat was consumed on the evaporation of this moisture, whereas soil with the horizontal surface (weather station site) rapidly and evenly was warmed thoroughly and was dried up. In this the leading role plays also the large consolidation of soil on meterological site.

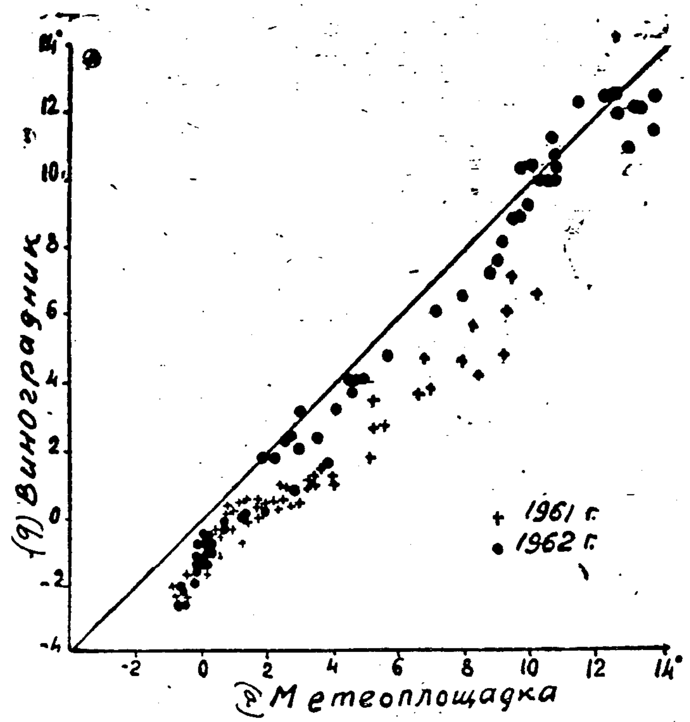

Fig. 4. - the graph of connection of soil temperatures at depths of 20 cm on the instrument platform and on the grape rise in January-March. of 1961, 1962.

Key: (a). Weather station site. (b). Vineyard.

Page 131.

In 1962 with the large dryness of the soil of heated rise and horizontal surface went approximately with one intensity, and at the end of March, when the height of sun above horizons increased, the days became longer and the observed overall temperature rise, in the daytime was warmed thoroughly even on 0.5-1.0° are stronger than meterological site.

Thus, in the humid springs the northern weakly warmed slopes of

the grape rises the course of the heating of upper 20 cm of the layer of the earth is considerably reduced, then with the dry soil of this reduction, in comparison with horizontal surface, is barely observed, since the rise of "humid rear" it is not formed.

The intense heating of grape rise in ILLEGIBLE frequently leads to the fact that the nodules un opened grape bushes rapidly will swell underground, and during ILLEGIBLE easily are damaged from the mechanical shock.

To avoid similar phenomena, in our opinion, it is necessary in the dry winters and springs to carry out winter or early spring irrigations, which would contribute to slower heating of the soil of vineyards, and thus lowering the probability of premature swelling of nodules underground.

The ratio of temperatures of grape stone and meterological station in deeper layers (40-80 cm) of preservation by the same, as at the depth of 20 cm, i.e., always on meterological site is 1.5-2.0° warmer than in the grape rise. However the lower layers the course of temperature is more even and oscillations are small (see Fig. 5).

Summing up that outlined above, it is possible to make the following basic conclusions.

1. In the cold period of year on sheltered vineyards are created

peculiar microclimatic conditions, the dominant role plays by the topography of vineyards, i.e., ILLEGIBLE blown between themselves numbers of positive and negative forms of relief.

Pages 132-133.

[No Typing].

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION	MICROFICHE
B085 DIA/RTS-2FI	1
C509 BALLOC509 BALLISTIC RES LAB	1
C510 R&T LABS/AVEADCOM	1
C513 ARRADCOM	1
C535 AVRADCOM/TSARCOM	1
C539 TRASANA	1
Q592 FSTC	4
Q619 MSIC REDSTONE	1
Q008 NTIC	1
Q043 AFMIC-IS	1
E404 AEDC/DOF	1
E410 AFDTC/IN	1
E429 SD/IND	1
P005 DOE/ISA/DDI	1
1051 AFIT/LDE	1
P090 NSA/CDB	1

Microfiche Nbr: FTD95C000561
NAIC-ID(RS)T-0302-95